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WAGLER ORIOLE
ICTERUS WAGLERI
One-half natural size

Painting by Andrew Jackson Grayson

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ECOLOGIC OVERLAP OF ALLEN AND ANNA HUMMINGBIRDS NESTING AT SANTA CRUZ, CALIFORNIA

By KEN LEGG and FRANK A. PITELKA

If different species of birds or other animals overlap in their occupation of habitat, and if their requirements are more or less similar, there is reason to expect that they may compete. To study such competition in natural populations, it is necessary to gather evidence on aggression between members of the respective species, on their density levels and shifts in populations, and on related matters. These are rather large objectives considering how difficult it is to deal with such problems in the field. Nonetheless, it was thinking along these lines that motivated this study of nesting Allen and Anna hummingbirds (*Selasphorus sasin* and *Calypte anna*) at Santa Cruz, California, from November, 1953, through the breeding season of 1955.

That there may be reduction of densities of breeding males of these two species in areas of overlap has already been reported (Pitelka, 1951b). For females, information is lacking. They nest in habitats different from those occupied by breeding males; and as no pair-bond is formed, nesting sites show no consistent relation to display territories of males (Pitelka, 1942). The nesting of the Allen Hummingbird has been studied in some detail (Aldrich, 1945), and the fact of overlap in the activity of nesting females of the two species is also known (Pitelka, 1951a). However, to date no serious attention has been given to the interrelations of nesting females on areas where both species occur.

This paper is based on observations in such an area. Because the field work had to be terminated after two years, the results are only preliminary and suggestive. Although the main stress is placed on data concerning females, the territoriality, aggressive behavior, and relative abundance of males are reported when they add significantly to the local picture or to information available in the literature.

All field work was carried out by Legg, and the first draft of this paper was prepared by him. The study was planned and carried out with suggestions from Pitelka, who then collaborated in the preparation of data and text for publication. The final versions of the maps shown in figure 1 were prepared by Mrs. Lois C. Stone, to whom the authors express their gratitude.

STUDY AREA

The study area, about six acres in size, included an entire small canyon located in the Natural Bridges State Park, Santa Cruz, California, at the north end of Monterey Bay. This canyon runs approximately north and south, and it varies in elevation from ten feet above sea level in the bottom to fifty feet at the rim. Both the north and south ends are bounded by city streets.

The length of the canyon is 1200 feet. The area was divided into twelve equal sectors of 100 feet each to facilitate accurate plotting of nest sites. The width of the canyon increases gradually from 100 feet at the north end to 450 feet at the widest point (fig. 1). A winter stream carries run-off water from the hills to the north. This stream forms a pond at the south end of the canyon which gradually dries up in late summer and refills in winter. It always contains water through the breeding season. The south

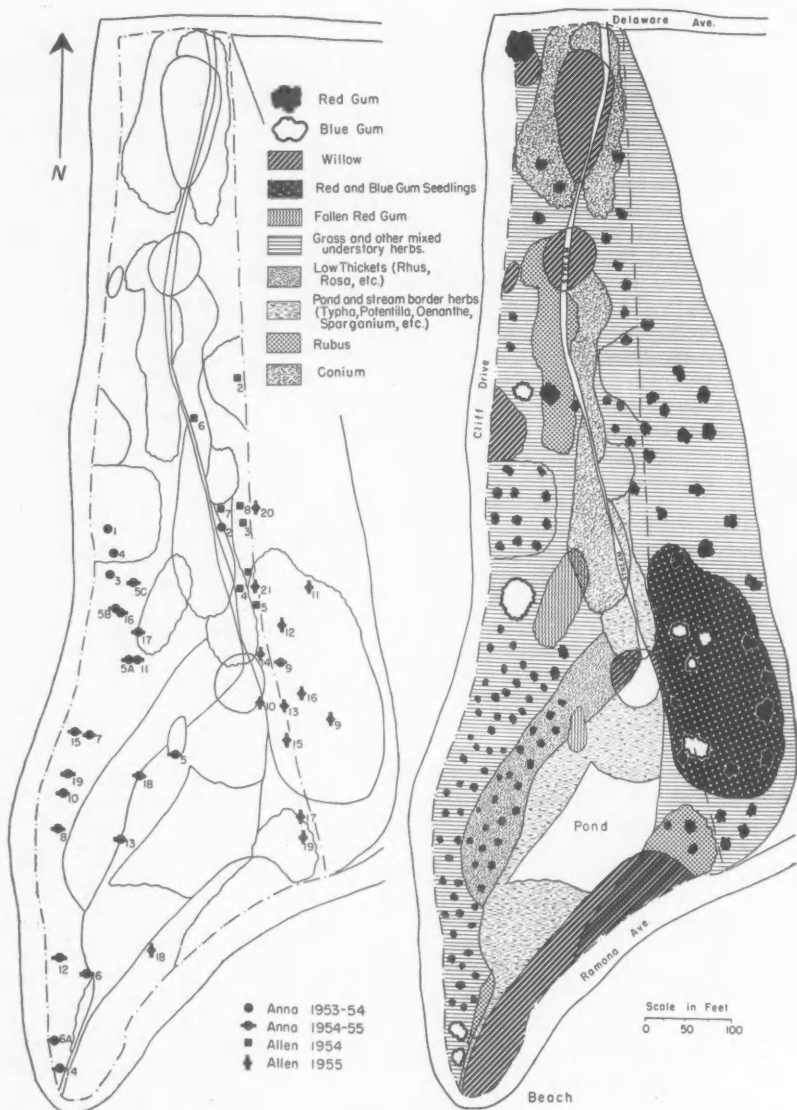


Fig. 1. Right, map of East Canyon, Natural Bridges State Park, Santa Cruz, California, showing approximate distribution of the chief vegetation types. Left, locations of nests of the Anna and Allen hummingbirds found in two successive seasons.

end of the canyon opens out onto a sandy beach with scattered, low clumps of willows. The south boundary of the study area is six hundred feet from the ocean shore.

Eucalyptus of two species, *Eucalyptus globulus*, hereafter referred to as blue gum, and *Eucalyptus amygdalina* or red gum are the only trees present except for groups of *Salix*, most of which are confined to the canyon bottom (fig. 1). Both species of hummingbirds use eucalyptus trees and bushes more than any other plant; this use includes perching, feeding, and nesting.

To the south on the study area, approximately one-half of the west slope is covered by red gum (fig. 2). These trees, many of which are multi-stemmed, are stunted because of shallow soil on the underlying shale, and few have grown beyond a four-inch diameter. They are fairly closely spaced, averaging six feet apart. The average height of these spindly trees is thirty feet. It was here that most of the nests of the Anna Hummingbird were found (figs. 1 and 2). Two large blue gums grow in this area. The northern half of the west slope supports a mixture of widely spaced red gums, several blue gums, willow clumps, and open areas occupied chiefly by *Conium* or *Rubus*.

On the east slope, the northern one-third supports relatively few trees, but near the center of this sector is a group of red gums most of which are large in diameter (8-10 inches) and 40 to 60 feet tall. There is an extensive group of willows in the north-central sector. East and north of the pond is a group of willows bounded by several large blue gums. Around these parent trees, and covering an area of about one hundred square feet, is a close-set group of blue gum seedlings. Most of the nesting area of the Allen Hummingbirds was confined to this section (fig. 3). Over these seedlings, larger trees of red gum form an upper story. The extreme south end is dominated by willow with *Rubus* as an understory.

SEASONAL OCCURRENCE AND POPULATION LEVELS

The first hummingbird that could be regarded as a breeding or potentially breeding individual was noted in the area on December 9, 1953, when a male Anna was heard singing from a perch forty feet up in a flowering blue gum. On December 18 a pursuit between a male and a female Anna was observed, and on the 25th a female was gathering nest material. One or two Anna Hummingbirds were probably present in the area throughout the year, but there was a decided influx of females around January 1, 1954.

In the same season, 1953-54, the first Allen Hummingbirds, both a male and a female, were seen on February 8. After nesting, Allen Hummingbirds appear to leave the canyon early, possibly due to the scarcity of flowering plants. The last Allen was seen in the study area on August 8, but one was seen in Santa Cruz nearby as late as October 3.

On April 1, 1955, a careful estimate was made of the numbers of both species. The population at that time was thought to be about five females of *anna* (breeders or potential breeders), and no males, except birds of the year. At least two adult males were present on the outskirts of the study area, and they may have come into the canyon periodically. Of *sasin*, fifteen breeding females and seven adult males were present, and possibly a few young. Males were easily and accurately counted due to their presence in established territories and their habit of holding prominent, regularly occupied perches.

Thus, the breeding density of the two species of hummingbirds together on the study area may be estimated at 27 individuals on six acres or, converted to a standard expression of density, 450 per 100 acres. It is evident from the preceding remarks regarding young and the occasional visits of adult males of *anna* that this is a minimal estimate of the total numbers present.

The number of nests found in the two breeding seasons is not an accurate basis for

estimating populations of females of the two species, as, from the first year to the second, success in location of nests improved considerably. For the Allen Hummingbird, there were more females in 1953-54 than in 1954-55; but for the Anna Hummingbird, the situation was reversed, and there were more females in 1954-55 than in 1953-54.



Fig. 2. Area of red gum on west side of canyon in Natural Bridges State Park; this was the main nesting area of the Anna Hummingbird.

In the two breeding seasons together, 44 nests were found in the study area, 23 of *anna* and 21 of *sasin*. In 1953-54, four *anna* and eight *sasin* nests were found; and in 1954-55, 19 *anna* and 13 *sasin* nests were recorded (table 1). These figures include all located nests, and hence also the successive nests of certain individual females.

In 1953, the first *anna* nest, then under construction, was found on December 29; in 1954, the first nest, in beginning stages of construction, was found one week earlier, on December 22. *Calypte anna* has young by the time *Selasphorus sasin* arrives. On February 8, 1955, an Anna Hummingbird was feeding young at nest 5C.

NESTING HABITATS

The types of nesting sites used by the two species on the study area are shown in figures 2 and 3. *C. anna* chose, almost exclusively, the more open west slope where tall red gum trees were predominant. By contrast, *S. sasin* often utilized as nest sites the more dense, less illuminated area of blue gum seedlings. Some nests (about one-half), however, were in situations similar to those of *anna* but on the east side of the canyon.

Nests of *anna* were placed higher than those of *sasin*, the lowest *anna* nest being ten feet above the ground. One *sasin* nest was 18 inches from the ground. Average

height of *sasin* nests was 18.5 feet; average height of known *anna* nests was 27.5 feet, and the actual figure is probably higher. Nests of *anna* were all in red gums. Nests of *sasin* were 42.8 per cent in blue gum, 47.6 per cent in red gum, 4.8 per cent in *Salix*, and 4.8 per cent in *Rubus*.



Fig. 3. Area of blue gums, including parent trees and many seedlings; this was the main nesting area of the Allen Hummingbird.

NEST BUILDING

The length of time required for completion of the nest in *anna* varies. Early nests, in December and January, are built more slowly; the time may occupy a month or more. One nest was built in two days. On February 24, 1955, the first down of this nest was placed. On the 25th, the nest was a cup with green lichens on outer walls. At 1:00 p.m. on February 27 the bird was incubating two eggs. At this nest, when building was underway, trips with material were made every 20 or 30 seconds.

Locations of early nests of *anna* are frequently changed. In some instances at least, this is brought about by bad weather. In the first season, from suggestive observations on one female, we could only speculate that she was shifting the location of her nest. Closer watching the following year, however, removed all doubt. Female 5 of *Calypte anna* (table 1) moved her nest location three times before she found one at which nesting then proceeded.

In 1954, the first nest (number 5 of table 1) was begun probably on the morning of December 22. On December 25, what was apparently the same bird was seen in the act of taking material from this nest and moving it to another site (5A). On January 3, she was taking this newly placed material to still another location (5B), 40 feet away. A

Table 1
Dates, Locations, and Fates of 44 Nests of Hummingbirds

Species and season	Nest no.	Date found	Stage when found	Date nest completed	Fate	Plant cover	Height in feet	Successful
<i>C. anna</i>								
1953-54	1	Dec. 29	Building	Jan. 9	?	Red gum	?	No
	2	Jan. 22	Completed	Feb. 13	Destroyed by storm	Red gum	40	No
	3	Jan. 30	Building	Feb. 26	Destroyed	Red gum	20	No
	4	Feb. 21	Completed	Apr. 8	Young fledged	Red gum	25	Yes
1954-55	5	Dec. 22	Just begun	Dec. 24	Moved	Red gum	20	No
	5A	Dec. 25	Building	Dec. 31	Moved	Red gum	40	No
	5B	Jan. 3	Building	Jan. 5	Moved	Red gum	?	No
	5C	Jan. 8	Building	Feb. 27	Young fledged	Red gum	20	Yes
	6	Dec. 25	Building	Jan. 5	Nest not completed	Red gum	40	No
	6A	Jan. 11	Completed	Feb. 1	Young fledged ?	Red gum	50	Yes ?
	7	Feb. 8	Nearly completed	Mar. 27	Young fledged	Red gum	20	Yes
	8	Feb. 24	Just begun	Mar. 16	Deserted	Red gum	15	No
	9	Mar. 13	Building	Apr. 29	Young fledged	Red gum	10	Yes
	10	Mar. 22	Building	?	?	Red gum	25	No
	11	Mar. 23	Incubating	Apr. 18	Young fledged	Red gum	25	Yes
	12	Mar. 26	Building	Apr. 5	?	Red gum	30	No
	13	Apr. 12	Building	?	?	Red gum	?	No ?
	14	Apr. 29	Nearly completed	?	?	Red gum	25	?
	15	Apr. 30	Building	?	?	Red gum	25	?
	16	May 4	Half-built	?	?	Red gum	30	?
	17	May 14	Completed	May 21	Abandoned	Red gum	35	No
	18	May 24	Completed	?	Young fledged	Red gum	25	Yes
	19	June 8	Incubating	?	Young fledged ?	Red gum	30	Yes ?
<i>S. sasin</i>								
1954	1	Feb. 21	Just begun	Apr. 28	?	Red gum	30	?
	2	Feb. 28	Eggs ?	?	?	Red gum	35	?
	3	Mar. 13	Incubating	Apr. 8	Young fledged	Blue gum seedling	4	Yes
	4	Mar. 13	Nearly completed	Apr. 18	Young destroyed	Blue gum seedling	4	No
	5	Mar. 13	Just begun	?	Nest not completed	Red gum	20	No
	6	Apr. 12	One egg	?	Destroyed	Blue gum seedling	10	No
	7	Apr. 12	Completed	?	?	Red gum	20	?
	8	Apr. 14	Incubating	Apr. 19	Destroyed	Blue gum seedling	?	No
1955	9	Mar. 1	Completed	?	Probably destroyed	Red gum	20	No
	10	Mar. 1	Just begun	Mar. 18	Deserted	Salix	25	No
	11	Mar. 11	Just begun	Apr. 18	Young fledged ?	Red gum	20	Yes ?
	12	Mar. 11	Just begun	Mar. 13	Abandoned	Red gum	25	No
	13	Mar. 15	Building	Mar. 18	Fell down	Red gum	25	No
	14	Mar. 15	Just begun	Mar. 22	Abandoned	Blue gum seedling	20	No

Table 1 (continued)

Species and season	Nest no.	Date found	Stage when found	Date nest completed	Fate	Plant cover	Height in feet	Successful
	15	Mar. 15	Completed	?	Young fledged ?	Blue gum	30	Yes ?
	16	Apr. 2	Just begun	Apr. 4	Abandoned	Blue gum seedling	10	No
	17	Apr. 7	Half completed	Apr. 10	Abandoned	Red gum	25	No
	18	Apr. 20	Half completed	June 5	Young fledged	<i>Rubus</i>	4	Yes
	19	May 11	Incubating	May 27	Destroyed	Blue gum seedling	1½	No
	20	May 15	Building	May 18	Nest not completed	Red gum	40	No
	21	May 16	Incubating	May 27	Destroyed	Blue gum seedling	2½	No

strong wind broke one of the twigs supporting the nest and caused it to tilt. At the time of the accident nest 5B appeared to be completely built. On January 8, she was watched taking material from this nest and transporting it to another site 20 feet north of 5B, to location 5C. January 15 through 19 were cold rainy days with ice on puddles in the mornings. By this time nest 5C contained eggs; the incubating female huddled low in the nest and was not seen to go for food at any time when rain was falling. On February 8 she was feeding young.

This female *anna* was not marked but it was apparent that she was one and the same bird. She was then the only female in the area. Although another was nesting, and also made one nest-location shift, in the south end of the canyon, this was some distance away, and many hours of observation each day permitted Legg to become familiar enough with the first female's movements and behavior to be reasonably sure that it was the same individual.

No nest-building in the Allen Hummingbird was observed at length, but both species appear to have similar methods of building. Several nests of *anna* were found when first, or near-first, material was placed. A wad of down was set on a limb, then bound with spider webs. Material brought to the nest consisted of webs or down. Usually these trips were made so that down was brought on three or four successive ones, then webbing on two or more successive ones, then down again, and so forth.

Nest building begins shortly after morning feeding, which occurs early, just after daybreak. It continues at an active pace until about eleven o'clock, then slowly comes to a standstill in the afternoon.

Some Californian naturalists believed they could identify the species of hummingbird responsible for a nest by structural features of the nest. In an area where both Allen and Anna hummingbirds nest, this may be true. Here, at Santa Cruz, most Allen nests were composed of brownish materials, whereas Anna nests were white, or gray. Anna nests, in the main, were smaller, and more shallow; Allen nests were usually taller and more bulky. There were, however, exceptions to this, some Anna nests being quite long and also bulky.

These structural differences seem to be correlated with the type of nest location. For the most part Anna nests were pad-like cups placed upon large solid surfaces. Those which incorporated, or were built upon, twigs usually were of similar size and shape to those of the Allen Hummingbird.

Color differences in nest structure are the result of different materials used. The Allen Hummingbird used bits of shredded eucalyptus bark, whereas the Anna Hum-

mingbird used some shredded fibers from the gray-colored stems of dead herbaceous plants such as the bristly ox-tongue (*Picris echioides*). Most Anna nests were composed mainly of cattail down. A few early Allen nests included the same material until willow down became available.

No examples of re-use of the nest structure were observed, nor was a new nest ever seen to be constructed on top of an old one. Old nests, by the time young depart, are badly disheveled and probably unusable. However, in many cases the materials are transported to another location and re-used.

A nest being dismantled assumes the appearance of an apple being pared down by a peeler going around and around until nothing remains. The bird hovers beside the nest and works around the cup, jabbing at it and pulling backward from it until the walls are demolished. Then the pad is taken bit by bit.

It was relatively easy to speculate which females of either species were re-nesting. If the old nest disappeared a few days after young were fledged, it was thought that a second nesting was underway. Only near the end of the nesting season were old nests not utilized. If the original owner did not use the material from previous nests, other hummers discovered and used it in spite of the fact that webbing and down were much in evidence in the area.

TERRITORIAL RELATIONS AND AGGRESSIVE BEHAVIOR OF FEMALES

The nesting density of females was lower in *anna* than in *sasin* (fig. 1). In early March, 1955, four females of *anna* (6A, 7, 8, and 9; see table 1) were active, but the last female on the scene (nest 9) was forced to invade *sasin* territory (fig. 1). Nests of females 7 and 8 were then known; a third female considered to be 6A was also present then, but its nest, if it had one, was not located. Nests 10 to 12, representing three concurrently established *anna* females, were separated from each other by approximately two hundred feet.

Note the grouping of *anna* nests shown in figure 1. It is believed that each group represents but one female, all nests in the area having been constructed by the same individual, except that nest 5 belongs in the group containing 5A, 5B, and 5C. Nests 13 and 17 may have been built by another individual, thus setting the total number of breeding females at five. These comments refer to the nests of 1955. The interpretation is strengthened by the fact that there was but one active nest in each group at any one time.

Also in March of 1955, seven females of *sasin* (numbers 9-15 in table 1) had, or were building, nests all of which were within an area no greater than 200 feet long and 100 feet wide. But when Anna 9 moved into the territory, Allen 12 was forced to vacate. This was a case of an Anna female displacing an Allen female. No examples of Allen females moving into Anna territory were recorded.

One Allen nest was built in a willow that was barren of leaves. As buds began to burst and down became available, it was the most popular place in the canyon for material-gathering Allens, and often three or four would be in the willow grove at the same time. The local incubating female seemed almost to become frantic. Each time an intruder seeking nest material appeared, she left her nest and drove it off, but there was always at least one present. Her zone of defense was a 30-foot circle about the nest. Sometimes birds beneath the nest went unmolested, but all those above or on a level with it were driven off. So busy was she kept driving other females away that she deserted her eggs after one week.

One persistent case of thievery was observed. One Anna was building a nest, and each time she was absent another Anna would come and take away material. Once the

rightful owner arrived when the intruder was present and drove her off. This seemed to put an end to the thieving, for the nest was completed successfully.

In the early part of the breeding season, before Allen Hummingbirds arrive, there is little indication of quarreling among Anna Hummingbirds. Later, after the former species arrived, female Annas were often seen gathering nest material or feeding in the nesting area used by Allens. To a lesser degree female Allens penetrated Anna territory for food.

Why was it that no female Allens attempted to utilize the west side of the canyon? Was it because the terrain, exposure, vegetation and other features were not suitable, or was it because Anna females were already established here? Allen females visited the nesting area of Anna females only seldom, and those which did stray into this area were set upon and put to route. Anna females seemed to visit Allen nesting territories at will, both to feed and to gather nest material. Such intrusions were more frequent than the reverse, but nonetheless Anna females were occasionally pursued by nesting Allens.

In general, activity of Anna females spilled over into the main nesting area of Allen females more than the reverse. Also, it appeared that, given an instance of intrusion, an Allen female was less likely to escape a chase from an Anna territory than in the reverse situation. However, it is not possible to assume that Allen females would utilize the nesting area claimed by the Anna Hummingbird if the latter were absent. The usual nesting and feeding sites of Allen females fall outside of the Anna nesting area. Hence the intrusions of Allen females into such an area may best be considered merely incidental, conspicuous though an ensuing chase may be.

Among females, instances of *anna* driving *sasin* out of nesting territories were recorded in 1955 on February 25, March 15, and May 4; in addition, on April 18, a female *anna* pursuing a female *sasin* from the west slope was probably an example of the same situation. For *sasin*, we have records of females driving females of *anna* out of nesting territories on March 11, March 23, April 20, and April 29. On March 29, an *anna* female was seen pursued by two females of *sasin*. These are records of chases in which the participants were satisfactorily identified, but the figures of four instances in favor of *anna* and five instances in favor of *sasin* mean little, not only for the reasons given above, but more importantly for the reason that in many encounters and chases witnessed, the participants could not be identified.

Breeding females of both species were seen to pursue Pileolated Warblers (*Wilsonia pusilla*), Chestnut-backed Chickadees (*Parus rufescens*), Audubon Warblers (*Dendroica auduboni*), and House Finches (*Carpodacus mexicanus*) when individuals of these species came too close to their nests. Both Sparrow Hawks (*Falco sparverius*) and Red-tailed Hawks (*Buteo jamaicensis*) were pursued in mid-air by hummers. On June 17, 1955, at least a dozen Allens and several Annas, all "ticking" excitedly, mobbed a sleepy Screech Owl (*Otus asio*) that perched in a seedling blue gum.

Although most Allen Hummingbirds were belligerent to blundering Chestnut-backed Chickadees which came too close to their nests, one female *sasin* nested within 10 feet of a chickadee's nest with young which was in a knot-hole. The parents made frequent trips to the hole with food, but the hummer paid no attention to them.

OTHER OBSERVATIONS ON NESTING

For 32 nests whose outcome is known (table 1), percentage of success is low, 30 per cent for Anna and 12 per cent for Allen. If the number of nests is increased to 37 to include those that were probably successful, the estimates of nesting success increase to 40 per cent for Anna and 24 for Allen.

In 1954 it was strongly suspected that an Allen was building a nest fifteen feet from

where she was feeding a single young. Both were one-egg nests. A chance actually to observe such dual nesting by an Anna came on March 22, 1955, when Anna 7 had nearly full grown young. This bird was seen building another nest 60 feet distant (nest 10) and making trips to feed her nestlings alternately. Cogswell (1949) reported alternated care of two nests by the Black-chinned Hummingbird (*Archilochus alexandri*).

Anna females were much more at ease on their nests than were Allens, as reported by Aldrich (1945:147). Incubating and brooding Annas were quiet, still, and unaffected by nearby intruders, seeming to depend upon immobility for protection. By contrast, Allen females turned the head, seemed excited, and squealed whenever another hummer came within 100 feet of the nest.

TERRITORIAL RELATIONS AND AGGRESSIVE BEHAVIOR OF MALES

No special attempt was made to study the displays of the two species. Due to the height at which most of this activity occurred and to the screening effect of the vegetational canopy, little was seen of this phase of the Anna Hummingbird's behavior. Also, males of this species were relatively scarce on the study area after January. However, observations on territorial and display behavior considered to be of interest are reported here.

The male Anna Hummingbird may begin its territorial displays in November. On November 6, 1954, a male was heard diving, and a few seconds later it was observed in pursuit of a female.

On several occasions when females of *anna* were observed constructing their nests, males were seen to come within a foot or so of the nest. These visits by the male always terminated in a pursuit, sometimes by the male, at other times by the female. These occasions produced longer absences from the nest than any other activity of the female.

After January, and more particularly after males of the Allen Hummingbird arrived, adult males of the Anna Hummingbird were present regularly only on adjacent uplands with open brush cover.

In the Allen Hummingbird, both sexes were usually much in evidence in the canyon bottom, and frequent opportunity was afforded to witness their activities closely. In this species, territorial display and mating begin as soon as the males arrive. Unlike the Anna males which came to nest sites in the course of construction, I witnessed only one male Allen in a nest territory when his presence was not the result of feeding or incidental passage through the area. This occurred on April 27, 1955: A female was seen to go to a perch about ten feet from her nest. She may have spotted a cruising male, for she gave one squeal. The male immediately appeared and began to display above her.

By the last of April displays and pursuits of the Allen Hummingbird subside. Aggressive behavior declines decidedly after May 15. After this time, weak and more or less incomplete flight displays are seen. Any portion of the display may be omitted. A pendulum may be executed without the terminal tail-movements and "clicking." Pendulums may be executed over females but may not be followed by "towering," the male merely flying off to a perch. Silent pendulum display-flights are common after June first. The last date on which I saw a silent pendulum flight of a male over a female was July 8. Later she made several trips with nest material to a site, but the nest was never completed. On April 24, 1955, a female *sasin*, accompanied by a fledgling, supposedly her's, set off a display when she and her offspring appeared in a male's territory.

Among Allen males, there appeared to be two types of territories in the study area, one for feeding, the other for prenuptial display and mating. Feeding territories were small, many in number, and usually the scenes of much confusion and contesting. A

single large blue gum at the height of the flowering season may provide four or five rather loosely held, defended areas. Here territories may even be vertically distributed, and a single large limb with a profusion of blossoms may constitute a territory held by one individual for a week or more. It is practically impossible to unravel the activities about such situations.

Breeding territories are more formally established, readily defined and easily observed. Indeed, in many cases the defending male may occupy the same perch day after day, although alternate perches may be used under different weather conditions. For example, on a warm, sunny day, the perch may be the top-most branch of a willow, the highest perch in the territory; on drizzly or foggy days, the perch may be under a canopy of over-hanging leaves in a red gum tree.

Adjacent territories of male Allen Hummingbirds are usually sharply defined. In the Natural Bridges canyon there were three territories in a row, each separated from the other by vegetational screens. These were located in the north end where there was no nesting activity. However, other males were located above nesting areas, in and around the tops of tall blue gums. One male Allen set up a territory just north of the pond (fig. 1) and directly between two nesting territories, one held by a female *anna*, the other by a female *sasin*. He had a small open area not over 50 feet in diameter in which he successfully maintained his position.

At times, territorial males do not react as expected. Although they are usually quite efficient at sighting and routing an intruder, instances are recorded where an outsider appeared, but, for some unknown reason, was not pursued. On February 23, 1955, Legg witnessed such an incident: One male Allen was feeding, probing damp willow leaves, presumably for insects. Presently a second male came into the area. Both flew to and perched on dead *Conium* stalks about six feet above the ground and ten feet from each other. Ordinarily a clash would occur, but here neither bird reacted. Presently one flew down the canyon, and the other returned to his feeding. Some males seemed never to become established but frequented the feeding areas and were found generally through the area.

About the middle of April, overall activity began to increase in the north part of the canyon as young of the year began to appear. At this time, and perhaps because adult males were less aggressive than a month or two previously, few of these young seemed to be molested. They succeeded in remaining in the area, and although there may have been some instances of young being driven out by established adults, none was witnessed.

On April 26 a young *anna* male settled on a small territory on the canyon slope below nesting territories of *anna* and defended it successfully against all comers until early in June. From his perch he poured out his squeaky, juvenal songs, and if any other hummer, of either species, entered this *Stachys* patch he was quickly chased.

Several records of territorial conflict between males of the two species were obtained. At Point Lobos Reserve, in Monterey County, on February 17, 1953, an Anna male was securely established in a territory overlooking a chaparral-covered slope. His constant perch was a specific twig of a *Ceanothus* bush. A female was seen gathering nest material in the near vicinity on the same date, and later a nest was found in pines not far away. Here were Anna hummers of both sexes, possibly a mated pair, established in a given area. But, on March 7, a male *sasin* occupied the same area and even the identical twig, keeping the territory throughout the summer.

On January 16, 1954, a male *anna* had a territory at the north end of the study area. He was observed here daily, where he perched in the top of a red gum and sang. On February 16, I observed a violent clash between him and a male Allen. The Allen chased the male Anna into a clump of willows from which came the sounds of chattering, squeal-

ing and the actual clash of wings. Presently the Allen came out, but the Anna was not seen to emerge. The following day, an Allen male had control of the north part of the canyon while an Anna was perched on a lone *Baccharis* shrub surrounded by an open field more than 100 yards away from the perch occupied earlier. The Anna male remained in the field all summer and, as far as I am aware, never challenged the Allen. Still another Anna which formerly had territory in the canyon withdrew to an open area to the eastward and likewise settled on a *Baccharis* bush shortly after Allen hummers arrived.

Trousdale (1954) states that "for the first time in our garden an Anna Hummingbird [male] succeeded in banishing an Allen Hummingbird [male]." Pitelka (1951b) also has indicated that *anna* may be successful in conflicts between males of the two species. In our experience at Santa Cruz, males of *sasin* consistently banish males of *anna* from territories. Pitelka (1951b) earlier has observed three instances of apparent displacement of *anna* males by *sasin* males. The reverse may be true between females of the two species, or at any rate, females of *anna* were secure in their nesting area and were seen regularly in the nesting area of *sasin*. If these opposing trends on the study area are real, they may balance each other, and there may be little margin of success favoring either species.

FEEDING

There were few flowering plants in the study area except the profusion of blue gum blossoms in the early part of the season. Both species of hummers were seen probing flowers of mustard, radish, blackberry, vetch, poison oak, hedge nettle, lupine, and morning glory. In early morning and late evening, when small flying insects could be seen in the air, many hummers were observed flying out and taking these.

On two occasions *anna* females were seen on the ground. Both appeared to be feeding. The tongue came into view repeatedly, and the throat muscles were also seen to move as though the bird were swallowing. Once the hummer was at a gravelly place; on the other occasion it was at an ash pile where brush had been burned. After watching what appeared to be feeding, I intentionally flushed the birds and immediately went to the sites to determine what it might be they were seeking. In both cases small ants were present at the spot where the birds had rested.

From the middle of April, and then throughout the summer, males and females of both species were frequently seen taking white flies (*Aleyrodidae*) from the foliage of *Rubus*. On May 15, 1955, I watched closely a young *anna*, which came within three feet of where I sat; it was feeding on white flies which covered the leaves of one of these berry bushes. Some of the insects adhered to the sides of the bill.

SUMMARY

Breeding populations of Allen and Anna hummingbirds (*Selasphorus sasin* and *Calypte anna*) were studied near Santa Cruz, California, in 1954 and 1955. The study area, about six acres in size, was a long narrow canyon in which the chief habitats were eucalyptus groves, willow thickets, and open areas with brush, tall herbs, and scattered eucalyptus trees.

The breeding population, on April 1, 1955, was estimated at five females of *anna* and 15 females and seven males of *sasin*. In 1954, while a population estimate was not obtained, it was known that there were more females of *sasin* and fewer of *anna*.

In these two years, 44 nests were found, 23 of *anna* and 21 of *sasin*. Early nests of *anna* may be moved as much as three times before the nesting gets underway. Building of early nests in *anna* may occupy a month or more; later nests may be built in no more

than two days. Nests of *anna* simultaneously active were spaced about 200 feet apart, whereas for *sasin* nesting density was higher, reaching seven females with simultaneously active nests on one-half acre.

Nesting success was at least 30 per cent in *anna*, but it was only 12 per cent in *sasin*; if additional nests which may have been successful are included, these figures increase to 40 and 24, respectively.

Males of the Allen Hummingbird held two types of territories in the breeding period, the relatively fixed mating territory already well described in the literature and a feeding territory variable in size and in period of occupation. Adult males of *anna*, supposedly territorial, occurred on the study area in November, December, and January; but after *sasin* arrived, they were present only on adjacent uplands with open brush cover.

In all of three instances of satisfactorily observed competition for territories among males, *sasin* displaced *anna*. Between females competing for nesting territories, one instance of displacement of *sasin* by *anna* was recorded, but none was noted showing the reverse. Territorial aggression by *anna* toward *sasin* and the reverse occurs in females as well as in males. On the study area, males of *sasin* were successful in displacing males of *anna*, and females of *anna* were able to hold their own against more numerous females of *sasin* and even to displace an occasional one. On this basis, it is suggested that in such coastal localities as exemplified by the study area, there may be little margin of success favoring either species in their overlap and competition with each other.

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WATER CONSUMPTION OF HOUSE FINCHES

By GEORGE A. BARTHOLOMEW and TOM J. CADE

Few data are available on the water requirements of wild birds, and only a few species which occur in the desert have been studied quantitatively in this respect. The House Finch (*Carpodacus mexicanus*) was selected for study partly because of its small size, hardiness in captivity, and availability, but primarily because its distribution in the desert is clearly related to the presence of surface water.

ACKNOWLEDGEMENTS

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METHODS

All of the experimental birds were trapped on the campus of the University of California, Los Angeles. They were housed in cages made of fish net of half-inch bar supported by a wire frame measuring 12×12×18 inches. The netting prevented the injury and feather abrasion which result when birds are held in small wire cages.

Water consumption.—The amount of water drunk was measured with graduated cylinders equipped with "L"-shaped glass drinking tubes (see Bartholomew and Dawson, 1954). The inverted cylinders were mounted on ringstands with the drinking tubes extending into the cages. Spillage due to jiggling of the drinking devices was avoided by arranging the drinking tubes so that they did not touch the cage and by shielding them with an arch of hardware cloth. One drinking device was used to determine evaporation. In each experiment the freshly captured birds were housed individually and given 24 to 36 hours to learn to use the drinking devices and to adjust to captivity. Food consisting of mixed bird seed was continually available. Except for the disturbances incidental to feeding and measuring water consumption, the birds were left completely alone.

During June and July, 18 House Finches were exposed for periods of 3 days to each of three different ambient temperatures. Temperatures were controlled either by a constant temperature cabinet equipped with lights, blower, heater, and refrigeration unit or by a similarly equipped constant temperature room. The photoperiod was controlled by automatic switches to approximate the day length normal in southern California for the season. Temperature and humidity were monitored by a recording hydrothermograph.

Water deprivation.—Two experiments were performed to determine the effects of water deprivation in the absence of temperature stress. Eight birds, captured in April, 1956, were housed in two cages with food and water available for the first 24 hours. The water was then removed and they were maintained on a diet of mixed bird seed for 48 hours after which water was again made available for four days to allow the birds to recover. After the period of recovery, water was again removed and the birds were maintained for seven days on a diet of bird seed and succulent vegetable food such as apples, celery tops, and lettuce. The birds were weighed at regular intervals throughout the experiments.

RESULTS

Water consumption.—Water consumption increased directly with increasing ambient temperature. The mean rate of water consumption was twice as great at 39° as at 20°C., but increased only about 40 per cent between 6 and 20°C. (fig. 1). At the two lower temperatures the birds were under no apparent stress, but at the highest temperature they appeared hyperactive, and some individuals panted almost continually. The mean water consumption at the highest temperature was over 40 per cent of the body

weight per day, and at this temperature three different birds drank more than 100 per cent of their body weight within single 24-hour periods. The body weights of the birds did not change significantly in the course of the experiments.

Water deprivation.—The results of the experiments are summarized in figures 2 and 3. In the absence of drinking water, the birds were unable to maintain their weight. After 48 hours they showed a mean loss of approximately 15.5 per cent of initial body weight. No changes in behavior were apparent during the period of water deprivation. As soon

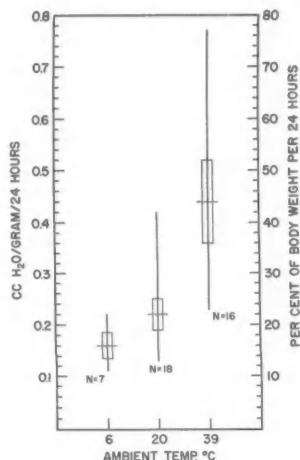


Fig. 1. The relation of water consumption of *Carpodacus mexicanus* to ambient temperature. The vertical lines indicate the range; the horizontal lines indicate the mean (M); the rectangles indicate the interval $M + 2\sigma_M$ to $M - 2\sigma_M$; and N indicates the number of birds used. The humidity mixing ratio (grams of H_2O /kilogram of dry air) at $6^\circ C$. was 4.36–5.01; at $20^\circ C$. it was 13.75–14.20 and at $39^\circ C$. it was 16.94–19.74.

as water was made available, the birds immediately began to drink. After 15 minutes the water was removed, and the birds were weighed. The mean increase in weight after drinking was 2.1 gm. or 12 per cent of the mean weight before drinking. Water was again made available, but the birds showed only slight interest in it. After 30 minutes, the water was removed, and the birds were weighed a second time. All but one had lost a little weight since the previous weighing, presumably as a result of defecation. Twenty-four hours later, with water continually available, the mean weight of the birds was above the starting level, all but one bird having regained or surpassed its initial body weight.

With succulent food available, but without water, caged House Finches were able to maintain a relatively constant body weight, after a slight initial drop, for at least a week (fig. 3). When water was made available on the last day of the experiment there was only a slight increase in body weight. This contrasts sharply with the more acute

experiment in which the birds had been maintained for 48 hours on dry food before water was offered.

In the course of the experiments on water deprivation, the behavior of the birds appeared normal, and none died. After the experiment with succulent food, autopsy showed some subcutaneous fat in the region of the feather tracts.

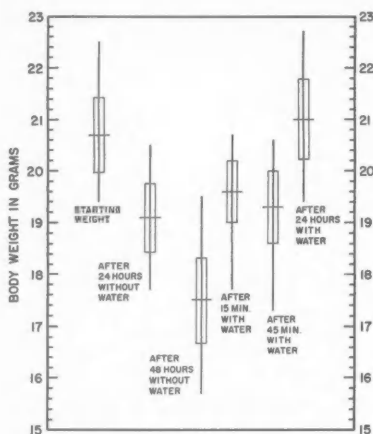


Fig. 2. Body weight in *Carpodacus mexicanus* during water deprivation. Ambient temperature 20–22 C.; relative humidity 54–68 per cent. Eight birds were used; symbolism same as in figure 1.

DISCUSSION

Ecology of House Finches in the desert.—House Finches are widely distributed in western North America and occur locally in all the major deserts where surface water is present (Salt, 1952). They often occur near springs, tanks, watering troughs for stock, and ranch houses which are surrounded by many miles of totally dry desert. Although primarily granivorous (Beal, 1904:34), House Finches eat various fruits, including cactus (Grinnell and Miller, 1944:454). Our data indicate that even at moderate temperatures House Finches need water equivalent to 20 per cent of body weight per day but that this requirement can be satisfied entirely by succulent plant food for days at a time. In the deserts of California succulent plant foods are most abundant during the latter part of the rainy season in late winter and spring. It seems probable that in this period when temperatures are still relatively moderate House Finches may occupy some desert areas without regard to the availability of surface water. As the season advances, however, high temperatures prevail, and succulent food becomes less abundant. Under these conditions House Finches, because of their large daily water requirements (as much as 100 per cent of body weight per day in hot weather), must have surface water not only within their daily cruising range (Grinnell and Miller, 1944) but within access for repeated drinks throughout the day. It is a matter of common observation that in hot weather House Finches remain in the immediate vicinity of water and bathe repeatedly. This repeated wetting of the feathers presumably facilitates temperature regula-

tion by evaporative cooling. It is probable that the populations of House Finches which occur on the coastal islands of California and northwestern Mexico can be almost independent of surface water throughout the year, for these islands which have little surface water are characterized by mild temperatures, high humidity, and an abundance of succulent vegetation.

Our laboratory data strongly support and help to explain the suggested habitat requirements of House Finches which Grinnell and Miller (1944:454) have proposed on the basis of field experience.

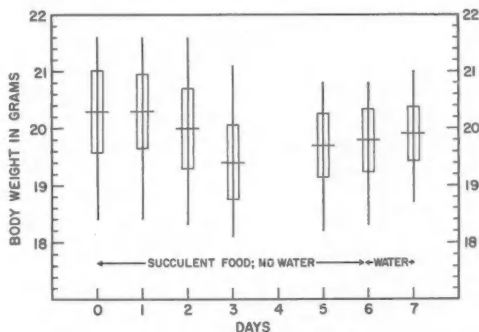


Fig. 3. Body weight in *Carpodacus mexicanus* during water deprivation but with succulent food available. Ambient temperature 20-22° C.; relative humidity, 56-68 per cent. Eight birds were used; symbolism same as in figure 1.

Water consumption and body size.—We have drawn from the literature and from our own unpublished data what little information is available on the water consumption of wild birds (fig. 4). Despite the differences in water content of the food which the various species eat and despite the different experimental conditions under which the data were obtained, an obvious correlation of water consumption with body weight is apparent, that is, the smaller the bird, the more water it drinks relative to its weight.

Weight-relative water consumption shows a curve which is strikingly similar to the curve for weight-relative respiratory water loss (Bartholomew and Dawson, 1953). Both desert and non-desert forms fall on the same curves. This strongly suggests that most desert birds, unlike many desert mammals, have not evolved special mechanisms for water conservation. Instead they appear merely to depend, as do most non-desert vertebrates, on drinking or on succulent food.

Factors affecting occupation of deserts.—The apparent lack of adaptive differences in water consumption between many desert and non-desert species offers an insight into the factors which have allowed the successful invasion of deserts by birds the major distributions of which are not in desert regions. Miller (1951) indicates that of the 274 species of birds which breed in California and about which adequate information is available only 17 show primary affinity for the desert scrub habitat and that an additional 23 species occupy the desert scrub as a part of their total distributions. Thus, about 60 per cent of the desert scrub avifauna consists of species which cannot be characterized as primarily desert birds. The ecological conclusions that we have drawn from data on water consumption and water loss are consistent with this distributional analysis. Thus, any bird which can satisfy its other habitat requirements in the desert is a candi-

date for establishment there because its physiology is apt to be as effective, from the standpoint of water economy, as that of most birds already occupying the desert.

A critical comparison may be made between the extremely eurytopic English Sparrow (*Passer domesticus*), originally from the cool moist British Isles, and the more stenotopic House Finch. One might expect the English Sparrow to enter accessible desert areas wherever surface water is available since its water economy would probably be

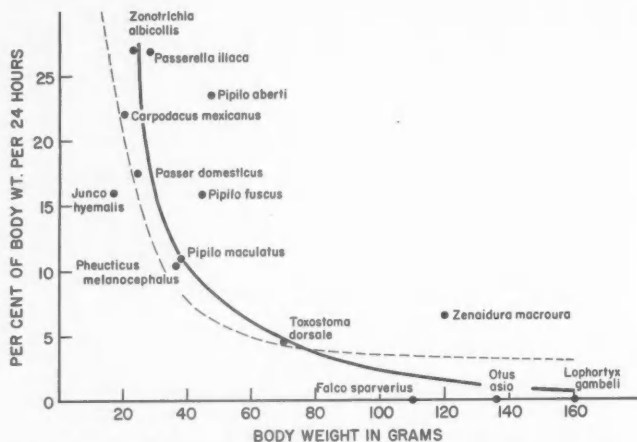


Fig. 4. The relation of water consumption, expressed as per cent of body weight per 24 hours, to body size at ambient temperatures of 20-23° C. The wide line is fitted by eye to the points shown. The thin, broken line shows respiratory water loss (taken from Bartholomew and Dawson, 1953) plotted on the same scale. The sources for the data on water consumption are as follows: *Zonotrichia albicollis*, *Passer domesticus*, and *Junco hyemalis* recalculated from Seibert (1949); *Pipilo aberti* and *Pipilo fuscus* from Dawson (1954); *Zenaidura macroura* from Bartholomew and Dawson (1954); and *Passerella iliaca*, *Pipilo maculatus*, *Pheucticus melanocephalus*, *Toxostoma dorsale*, *Otus asio*, and *Lophortyx gambeli* from Bartholomew and Dawson (unpublished data), and *Falco sparverius* from Cade (unpublished data).

comparable to that of most other species of passerines already occupying the desert. It has apparently done so repeatedly in the oases of the Old World and also very recently in the deserts of southwestern United States. As Grinnell (1919) has pointed out, it is widespread in areas of human occupancy throughout the desert regions and has successfully invaded Death Valley, California, which is probably the most extreme desert area in North America. The English Sparrow, introduced from the cool moist British Isles, thus is apparently able to occupy the New World deserts in exactly the same way as the House Finch, the evolution of which has presumably been closely tied to the xeric regions of western North America.

In severe deserts, where permanent surface water is absent for hundreds of square miles, birds are extremely scarce. Because of the high levels of water loss and water consumption in small birds, it appears unlikely that any herbivorous species smaller than the Gambel Quail (*Lophortyx gambeli*) can maintain itself without drinking water or eating succulent food. It seems possible that carnivorous birds such as hawks, owls, cap-

rimulgids, and insectivorous passerines might occupy waterless deserts by subsisting on the water in their food. It is of interest that those passerine birds, with the possible exception of the Black-throated Sparrow (*Amphispiza bilineata*), showing primary affinity for the desert scrub habitat (Miller, 1951) are largely insectivorous and thus are assured of water as long as they can find food. Other cases in point are offered by the American Kestrel (*Falco sparverius*) and the Screech Owl (*Otus asio*) which we have kept in captivity for several months without water. Whether or not the water available in animal food is sufficient to meet the demands of evaporative cooling at high ambient temperatures even for the larger raptors remains unknown.

Unfortunately the most critical species with regard to water economy of North American desert birds are yet to be studied. Such forms as the Black-throated Sparrow, the Rock Wren (*Salpinctes obsoletus*), and the Verdin (*Auriparus flaviceps*), which are small and do not appear to be water-dependent, remain completely unknown from the standpoint of water economy.

Despite the incompleteness of our present knowledge, it seems reasonable to hypothesize (1) that most desert birds have not evolved the special physiological mechanisms of water conservation comparable to those shown by many desert rodents, and (2) that the smaller the bird the more acute is its need for surface water, or failing that, a succulent diet.

SUMMARY

During June and July, 1955, 18 House Finches (*Carpodacus mexicanus*), captured on the campus of the University of California, Los Angeles, were exposed for periods of three days to each of three different ambient temperatures, and their water consumption was measured. The weights of these birds did not change significantly in the course of the experiments. Water consumption increased directly with ambient temperature and approximated 16 per cent of body weight per day at 6°, 22 per cent at 20°, and 44 per cent at 39°C.

Eight birds caught in April, 1956, and maintained on a diet of dry seeds without water lost about 15 per cent of their initial body weights in 48 hours at 20°C., but they made up their losses within 24 hours when water was again made available. At the same temperature but with succulent food available, these birds were able to maintain their body weights during a 7-day period without water.

Our data on water consumption of the House Finch help explain its pattern of distribution in the desert and supplement the analyses of its habitat requirements based on field observations.

The relative water consumption of those wild birds which have been studied decreases directly with increasing body size and shows a curve similar to that of respiratory water loss relative to weight. It is suggested that most desert birds have not evolved special mechanisms of water conservation and that the smaller the bird the more acute is its need for surface water, or failing that, a succulent diet.

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THE FOSSIL LOON, COLYMBOIDES MINUTUS

By ROBERT W. STORER

In recent years, most taxonomic work on birds has been at the level of the species and subspecies, while the interrelationships of the major groups of birds have received relatively little attention. The classifications set up before Darwin's time were based purely on similarities in structure; but with the acceptance of the concept of organic evolution, the corollary of convergence slowly became understood. This idea that two or more unrelated groups of organisms could, in the course of evolution, become superficially similar in both habits and structure is, of course, very important. Thus in order to understand the true relationship between two groups, common characters which are the result of convergent evolution must be distinguished from more conservative features which are indicators of actual phylogenetic relationships.

The diving birds provide excellent examples of convergence. Until the appearance of the fourth edition of the Check-List of North American Birds in 1931, the loons, grebes, and auks were all grouped in one order by most American ornithologists. Members of the auk tribe, which, unlike the loons and grebes, regularly use their wings for propulsion under water, are now believed to be related to the gulls. The loons and grebes have been put in separate orders, which, however, are kept side by side in the classifications of most workers.

The reasons for separating loons from grebes are many and fundamental. Among them are the differences in the texture of the plumage, the form of the tail feathers, the location of the nest, the number of eggs, and the webbed versus lobed toes. Stolpe (1935) made detailed anatomical studies and listed a number of perhaps more deep-seated characters. For instance, when a swimming loon brings its foot forward prior to making a stroke, the toes are folded together and brought straight forward, whereas a grebe turns the whole foot through an arc of 90° and brings it forward sideways. In grebes, the extension of the tibia over the knee joint is made up of both the tibia itself and the patella. In loons, the patella is minute and does not form part of this cnemial crest.

Considering that the wings and pectoral girdle are little, if at all, modified for the birds' aquatic habits, the shape of the sternum, coracoid, and, in fact, all the wing elements of loons and grebes are strikingly different. This evidence that loons and grebes were not derived from a common swimming ancestor, however, was long in being discovered, and its significance was obscured for many years by the description of the fossil known as *Colymboides minutus*. This bird was found in Aquitanian deposits—late Oligocene or early Miocene in age—of France. Three elements, the femur, the humerus, and the ulna, were described by Milne-Edwards (1867–1868). Writing at a time when the role of convergence in evolution was not well understood, he said of the osteological characters of the family of the "Colymbides" [loons and grebes] "Cette famille, comprenant les Plongeurs proprement dits et les Grèbes, constitue un groupe parfaitement naturel, dont tous les membres présentent entre eux de grands traits de ressemblance." (p. 278). He described *Colymboides minutus* as having the characters of both loons and grebes and concluded that it was intermediate between these groups of birds.

Since from the description, *Colymboides* was obviously a diving bird and since it was my conviction that loons and grebes could not have come from a common swimming ancestor, I several years ago studied Milne-Edwards' description and plates and came to the conclusion that this bird was probably a loon which had reached a degree of specialization equivalent to that of modern grebes and that the characters said to have been grebelike were the result of this. These tentative conclusions were laid aside in

manuscript form in the hope that I could at some future date examine the fossils themselves.

In the course of the Eleventh International Ornithological Congress, I visited the Naturhistorisches Museum in Basel and there saw several bones of *Colymboides* on exhibition. Upon inquiring, I found that the museum had a large collection of fossils from Aquitanian deposits, and Dr. Schaub kindly invited me to examine it. Accordingly, Dr. Wetmore and I again visited the museum, where we found approximately fifty bones which we assigned to this species. Included were well-preserved examples of the coracoid, humerus, radius, ulna, carpometacarpus, sacrum, femur, tibiotarsus, and tarsometatarsus. Comparisons with recent material in Basel showed that *Colymboides* was, as suspected, a primitive loon. Dr. Schaub kindly offered to lend the material for further study, and I took it to Paris, where not only the type of the species is located but also about fifty more bones, most of which had come into Milne-Edwards' possession after he had described the species. Subsequently, I was able to compare the material from Basel with the type (a coracoid) of *Colymboides anglicus* at the British Museum. In all, 110 bones of *Colymboides minutus* have been examined as follows: 3 coracoids, 31 humeri, 28 ulnas, 8 radii, 10 carpometacarpi, 2 synsacra, 14 femurs, 9 tibiotarsi, and 5 tarsometatarsi. For comparison, skeletons of the following Recent loons and grebes have been available: 5 Red-throated Loons (*Gavia stellata*), 1 Arctic Loon (*G. arctica*), 18 Common Loons (*G. immer*), 2 Yellow-billed Loons (*G. adamsii*), 2 Dabchicks (*Podiceps ruficollis*), 2 Least Grebes (*P. dominicus*), 5 Horned Grebes (*P. auritus*), 2 Eared Grebes (*P. caspicus*), 2 Great Crested Grebes (*P. cristatus*), 4 Red-necked Grebes (*P. grisegena*), 1 Western Grebe (*Aechmophorus occidentalis*), and 16 Pied-billed Grebes (*Podilymbus podiceps*), all in the collections of the University of Michigan Museum of Zoology.

I am indebted to the staffs of the Naturhistorisches Museum in Basel, the Museum d'Histoire Naturelle in Paris, and the British Museum (Natural History) for permission to study the material under their care and for many other courtesies. I also wish to thank William L. Brudon for preparing the figures, Prof. J. Berlioz for making comparisons in the Museum d'Histoire Naturelle, Dr. Andrew J. Berger for assistance in interpreting muscle scars on the fossils, and Drs. C. W. Hibbard and J. Van Tyne for reading the manuscript and offering valuable suggestions.

Montagna (1945) presents evidence that the digits of the birds' hand should be numbered II, III, and IV. However, until his work has been confirmed, I prefer to use the more familiar system which numbers the digits I, II, and III, particularly because a change in the numbering of the digits requires several awkward changes in the nomenclature of the muscles. Therefore, I have followed the nomenclature of Howard (1929) for all the bones and their parts.

Rather than present detailed series of measurements of the bones, only measurements of the lengths of the long bones are presented (table 1), which, with the photographs of the bones (figs. 1-3), should give a clearer idea of the fossils than exhaustive descriptions and measurements.

LIMB STRUCTURE

Limb proportions.—Because the loons and grebes are primarily foot-propelled diving birds, it is to be expected that the relative lengths of the leg bones should reflect the degree of specialization for swimming and diving. On the other hand, it might be argued that differences in the wing proportions of loons and grebes would more probably indicate differences of a phylogenetic nature. This appears to be the case. In table 2, it will be seen that grebes have relatively long ulnas and correspondingly short metacarpi as

Table 1

Lengths of Limb Bones of *Colymboides minutus* in Millimeters

Element	Number measured	Range	Mean
Humerus	18	62.0-66.0	63.8
Ulna	21	49.8-56.0	52.2
Radius	7	50.4-52.0	51.2
Carpometacarpus	10	31.0-34.5	32.8
Femur	6	28.9-33.0	30.9
Tibiotarsus without cnemial crest	3	55.0-59.2	56.8
Tarsometatarsus	4	30.8-32.8	32.2

compared with the loons. The agreement in these proportions within both the loons and the grebes is remarkable; and the resemblance of *Colymboides minutus* to the loons in these proportions is extremely close.

The ratio of total length of leg to total length of wing increases from the larger to the smaller species in both groups. This is to be expected because of the surface-volume ratio. That is, with an overall increase in length, weight increases more rapidly than wing area, hence in large birds, there must be a disproportionate increase in wing size in order to make flight possible. On the other hand, no such disproportionate increase in foot area is necessary because the force required to move a body through the water is

Table 2

Limb Proportions of *Colymboides minutus* and of Recent Loons and Grebes Expressed as Per Cent of the Lengths of the Limbs and Their Elements

	<i>Podiceps cristatus</i>	<i>Podilymbus podiceps</i>	<i>Podiceps dominicus</i>	<i>Colymboides minutus</i>	<i>Gavia adamsii</i>	<i>Gavia immer</i>	<i>Gavia stellata</i>
Number of individuals	2	16	2	*	2	18	5
<u>Femur</u>							
Total leg ¹	20.5	26.3	24.7	25.8	20.1	19.5	17.3
<u>Tibiotarsus²</u>							
Total leg	49.4	46.6	45.5	47.4	49.5	49.0	50.5
<u>Tarsometatarsus</u>							
Total leg	30.1	27.1	29.8	26.8	30.4	31.5	32.2
<u>Femur + cnemial crest</u>							
Total leg	29.7	33.8	32.7	33.2	37.2	37.2	37.8
<u>Total leg</u>							
Total wing ³	81.3	83.8	88.3	80.6	63.6	65.6	70.5
<u>Humerus</u>							
Total wing	42.7	41.9	41.4	42.9	43.2	43.7	42.6
<u>Ulna</u>							
Total wing	38.9	39.1	40.3	35.1	34.7	37.7	34.4
<u>Carpometacarpus</u>							
Total wing	18.3	19.0	18.4	22.0	22.1	22.6	23.0

* Calculations based on average measurements of 6 femurs, 3 tibiotarsi, 4 tarsometatarsi, 18 humeri, 7 ulnas, and 10 carpometacarpi.

¹ The sum of the lengths of the femur, tibiotarsus (minus the cnemial crest), and the tarsometatarsus.

² The length of the bone minus the length of the cnemial crest.

³ The sum of the lengths of the humerus, ulna, and carpometacarpus.

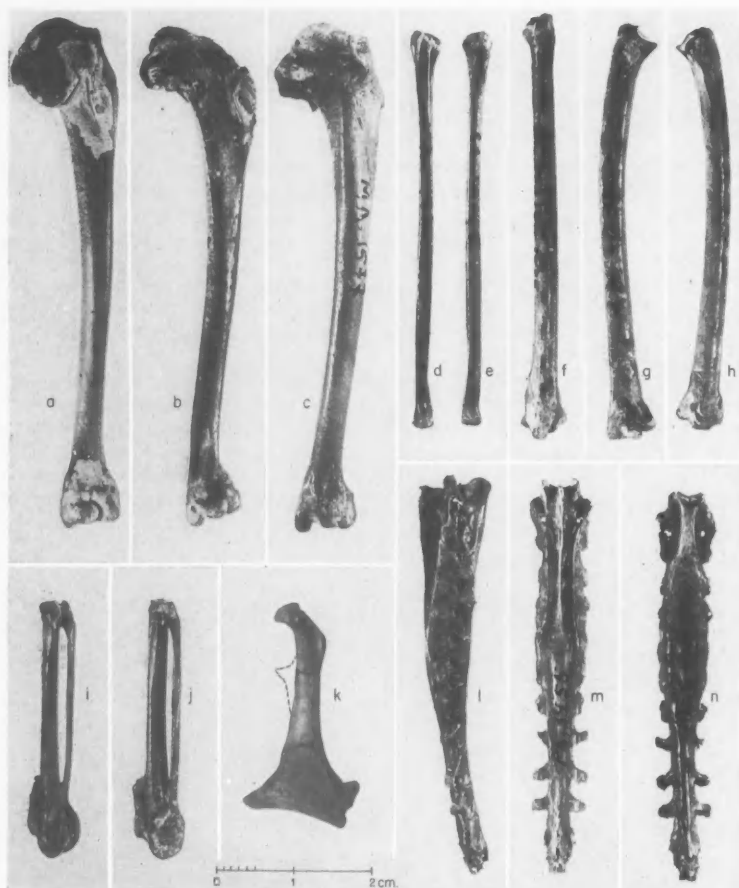


Fig. 1. Wing elements, coracoid, and synsacrum of *Colymboides minutus*: a (Ph. 2005), b (S.G. 20613), and c (M.A. 1577), humeri; d (M.A. 1626) and e (S.G. 20675), radii; f (S.G. 20652), g (M.A. 1614), and h (M.A. 9784), ulnas; i (M.A. 1646) and j (S.G. 5614), carpometacarpi; k, coracoid; l, m, and n (all Ph. 3455), synsacrum. Coracoid from the Museum d'Histoire Naturelle in Paris, other specimens from the Naturhistorisches Museum in Basel.

proportional to its cross-sectional area. In geometrically similar birds, the cross-sectional area and the area of the foot, which provides the propulsive power, increase at the same rate as the overall size of the bird increases.

When due allowance for the sizes of the different species is made, it becomes apparent that loons have a relatively low leg/wing ratio and that this ratio in *Colymboides* is significantly lower than that of grebes of approximately the same size. A relatively short femur and long tibiotarsus are found in both loons and grebes, and it is probable

that these proportions are indicative of the degree of adaptive modification for submarine locomotion. Using this as a criterion of the degree of modification, the loons can be regarded as more highly modified than the grebes. *Colymboides* resembles *Podilymbus* in this respect.

Colymboides also resembles *Podilymbus* in the combined relative lengths of the femur and cnemial crest. The proportion of this sum to the total length of the leg may be taken as an indication of the size of the attachment, and hence the size, of the gastrocnemius, the muscle most important in retracting the foot in swimming. In this, as in the relative lengths of the leg bones, the Recent loons are more modified adaptively than are the grebes and *Colymboides*.

Coracoid.—This element, more than any other part of the skeleton, proves *Colymboides* to have been a loon and eliminates any possibility of affinity with the grebes. Figures 1 and 4 show clearly the loonlike form of this bone. In grebes, the coracoid is relatively much longer and narrower, the procoracoid and the sternocoracoid process are but slightly developed, and there is a very large ventral sternal facet. Indeed, it is surprising to find such differences in birds which are so similarly adapted.

Had the coracoid of *Colymboides minutus* been known to Milne-Edwards when he described the species, I doubt that he would have suggested that this bird had any relationship with the grebes. Subsequently, he must have examined this element, for a beautifully preserved coracoid (fig. 1) in the Paris Museum bears a label which reads "*Colymboides minutus* A. M-Ed. Coracoidien. St. Gerand. Col. A. M. Edw. 1906-17." I cannot find any evidence of his having published a description of it.

Colymboides anglicus, described by Lydekker (1891:192-193) from the "Upper Eocene (Lower Oligocene) of Hordwell, Hampshire," England, is known from a coracoid (the type), shown in figure 4, and an "imperfect anterior portion of a sternum probably referable to this species." Of the latter, Lydekker states (p. 193) "the left coracoidal groove fits the preceding specimen [the type]. In the presence of a deep concavity in the middle line between the coracoidal grooves, the inner surface of this specimen agrees with the sternum of *Colymbus* [= *Gavia*], to which it approximates in the slight development of the episternal process." This fragmentary sternum may be lost, for it could not be found during my visit to the British Museum (Natural History) in June and July of 1954. Unfortunately, it has never been figured.

The coracoid of *C. anglicus* is approximately one-third larger than that of *C. minutus*, and the shaft of the bone is relatively more slender. Otherwise, the resemblance between the coracoids of these two species is remarkably close, and they almost certainly represent species belonging to the same genus. It is interesting that Lydekker should have placed *anglicus* in the genus *Colymboides*, because at the time he described this species, the coracoid of *C. minutus* was apparently unknown.

Humerus (figs. 1 and 3).—Both loons and grebes have slender humeri compared with birds which fly better and more frequently. This bone in *Colymboides minutus* is somewhat stouter than the humeri of either loons or grebes and thus appears to represent a condition intermediate between that of the Recent loons and an ancestral stock with more powerful wings.

The humeri of loons and grebes differ in several characters. On the proximal end of the bone, the bicipital furrow is deeper and narrower, the deltoid crest is more arched, and the head of the humerus is relatively larger in loons than in grebes. On the distal part of the bone, both the external and internal tricipital grooves are wider, slightly deeper, and extended further proximally on the shaft in loons than in grebes. In the loons, the shaft of the humerus is more S-shaped than it is in most species of grebes. The humerus of *Colymboides* agrees with those of Recent loons in all these characters,

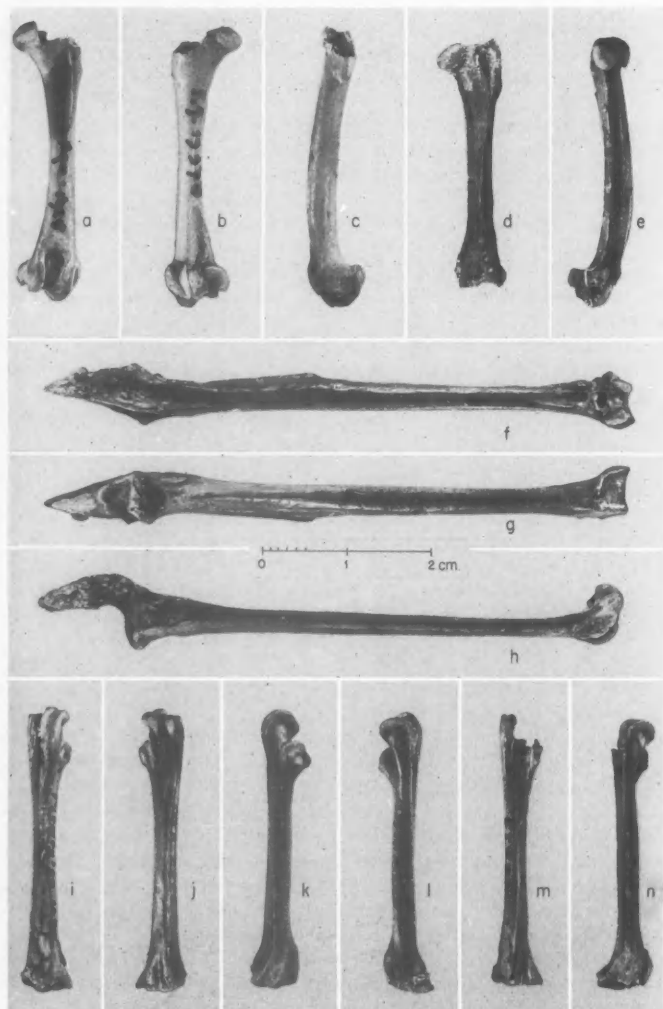


Fig. 2. Leg elements of *Colymboides minutus*: a, b, and c (all S.G. 19373), d (S.G. 6686), and e (M.A. 2627), femurs; f, g, and h (all S.G. 6702), tibiotarsi; i, j, k, and l (all M.A. 2668) and m and n (both S.G. 20829), tarsometatarsi. All from the Naturhistorisches Museum in Basel.

although the arching of the deltoid crest is even more pronounced than it is in any Recent loon.

Ulna (figs. 1 and 3).—The ulnas of loons and grebes differ in several important respects. Those of loons are much heavier and more circular (less triangular) in cross section. The ulna of *Colymboides* is quite loonlike in these respects and also in the

arrangement of the longitudinal intermuscular ridge on the anterior face of the bone. A striking feature of the ulnas of loons is the very much expanded carpal tuberosity. In *Colymboides*, this process is much larger than that of grebes, and although resembling that of loons in general form, it is less well developed. On the proximal end of the bone, the prominence for the anterior articular ligament is broad, high, and bordered posteriorly by a deep groove; in grebes, this prominence is narrower and less raised, and



Fig. 3. End views of limb bones of *Colymboides minutus*: a (M.A. 1646), proximal end of carpometacarpus; b (S.G. 6686), proximal end of femur; c (S.G. 19373), distal end of femur; d (S.G. 20829), proximal end of tarsometatarsus; e (M.A. 2668), distal end of tarsometatarsus; f (M.A. 1577), proximal end of humerus; g (S.G. 20613), distal end of humerus; h (M.A. 1614), proximal end of ulna; i (M.A. 2538), distal end of ulna. All specimens from the Naturhistorisches Museum in Basel.

there is no groove behind it. The corresponding prominence in *Colymboides* is broader than even those of Recent loons, but the posterior groove is not present. Milne-Edwards' description of the ulna of *Colymboides* (1867-1868:298) is very brief, mentioning only the laterally compressed distal end of the bone, its shortness as compared with the humerus, and its generally loonlike form.

On several ulnas of *Colymboides*, scars for the papillae of 11 secondaries can be counted, evidence of the remarkably fine state of preservation of these fossils. In both loons and grebes, there is variation in the number of these scars, so I doubt their value in macrotaxonomic work, at least in these two orders of birds.

Radius (fig. 1).—Like the ulnas, the radii of loons are relatively stouter than those of grebes. They are also straighter, having little of the pronounced "S" shape of grebes' radii. The radii of *Colymboides* closely resemble those of loons in both of these respects. Perhaps the most distinctive character in the radii of loons is the presence of a groove lying anterior and parallel to that for the tendon of the extensor metacarpi radialis muscle. This groove is present in *Colymboides* but absent in the grebes; and furthermore, the groove for the tendon of *M. extensor metacarpi radialis* extends well up onto the shaft of the radius in Recent loons (and in *Colymboides*) but little or not at all in grebes.

Carpometacarpus (figs. 1 and 3).—The most conspicuous feature of this bone in the loons is the long, narrow first metacarpal, which is approximately 33 per cent of the length of the whole bone as opposed to 16 per cent in grebes and 23 to 24 per cent in *Colymboides*. In grebes, the proximal end of the first metacarpal is expanded into a

prominence for the extensor attachment, whereas in loons this part of the bone is nearly straight and the extensor attachment is a flat, slightly depressed area. On the external face of the distal end of the carpometacarpus of loons, there are conspicuous tendinal grooves between the second and third metacarpals; these are not present in the carpometacarpus of grebes. In these characters, and also in the relatively wide intermetacarpal space and the shape of the carpal trochlea, *Colymboides* is loonlike. The relative shortness (for a loon) of the first metacarpal may be taken as evidence of an evolutionary tendency in loons.

Gaviella pusilla (Shufeldt), known from the proximal end of a carpometacarpus collected at Lusk, Wyoming, has been tentatively assigned to the White River Oligocene by Wetmore (1940). This fragment differs from the carpometacarpus of *Colymboides minutus* in being considerably larger, in having metacarpal I relatively higher, and in having the fused proximal portions of metacarpals II and III even longer, relatively, than those of *Gavia immer*. This bird appears to have been an off-shoot of the loons and has been given subfamilial status by Wetmore (*op. cit.*).

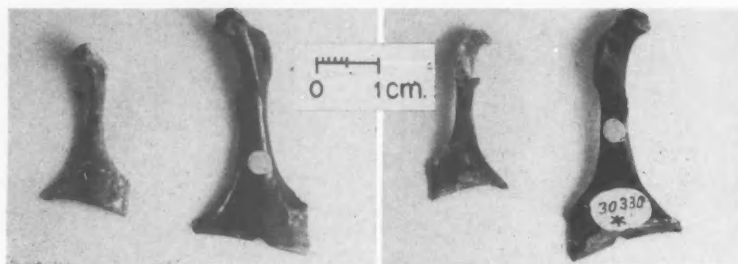


Fig. 4. Coracoids of *Colymboides minutus* (smaller) and *Colymboides anglicus* (larger), the former, an uncatalogued specimen in the Naturhistorisches Museum in Basel, the later, the type in the British Museum (Natural History). Photographs, courtesy of the British Museum.

Synsacrum (fig. 1).—Like the leg bones, the synsacrum indicates that *Colymboides* was a loon and was not nearly so modified for underwater locomotion as are the Recent loons. The synsacrum of *Colymboides* is broader than that of *Gavia*, especially in the caudal region, and the lateral processes of the caudal vertebrae are relatively longer and weaker. The pelvis was thus considerably broader in the fossil form.

In Recent loons, the extreme narrowing of the synsacrum and the accompanying shortening or disappearance of the lateral processes of the vertebrae make it difficult to classify the vertebrae. In *Colymboides* this is somewhat easier. Anteriorly in *Colymboides*, there is one thoracic vertebra bearing costal facets. In *Gavia*, there may be one, two, or three, two being the usual number in adults. Apparently there is some fusion as the birds get older. There are three lumbar vertebrae immediately anterior to the acetabulum in both genera; and although without costal facets, the anteriormost of these is intermediate between the other lumbar vertebrae and the last thoracic one in structure. Behind the lumbar series come three vertebrae which lack lateral processes and appear to be sacral vertebrae. The next vertebra bears a small process and is intermediate between the sacrals and the succeeding fused caudals in character. Counting this vertebra of intermediate type, there are usually seven fused caudals in *Gavia* and at least six in *Colymboides*. (The synsacra of both specimens available to me are broken in this region.) As in the case of the fused thoracic vertebrae, the number of fused caudal verte-

brae in *Gavia* increases with age. The number of fused vertebrae in *Colymboides* falls within the range of variation in *Gavia* but would appear to average less. It might be expected that in the process of becoming better adapted for diving, there would be an increase in the number of vertebrae fused into the synsacrum, and this appears to have been the case in the loons. One of the important differences between the synsacra of grebes and of loons (including *Colymboides*) is that in the former the lateral processes of one lumbar vertebra form the principal attachment with the ilia whereas in the latter, the processes of two lumbar vertebrae share in this attachment.

Femur (figs. 2 and 3).—Some of the important differences between the femurs of loons and those of grebes are found on the lateral face of the head of this bone. In grebes, the tendon of the ischiofemoralis muscle inserts in a conspicuous, nearly circular depression, which usually has a lip extending posteriorly; in the loons, the corresponding depression is usually elongate and never has a lip. In the grebes, the trochanteric ridge rises in a conspicuous, rounded projection distally, whereas it is nearly straight in the loons. In all of these characters, and also in the form of the rotular groove, the femur of *Colymboides minutus* is loonlike.

Although there is considerable variation from species to species, the femoral shafts of Recent loons are heavier than those of the grebes and *Colymboides*, particularly anteroposteriorly. I think that the relative thickness of the shaft is an expression of the degree of modification for diving and swimming and that the resemblance of *Colymboides* to some grebes, especially to *Podilymbus*, in this respect does not imply a phylogenetic relationship. It stands to reason that the loons must have passed through a stage comparable in its degree of adaptive modification to that now seen in *Podilymbus*.

The raised crest described by Milne-Edwards (1867-1868:298) as forming the internal border of the area of attachment of the "internal" (= medial) head of the gastrocnemius muscle is quite distinct in all the specimens which I have examined and has no counterpart in either the loons or the grebes.

As Milne-Edwards noted (*loc. cit.*), some of the femurs of *Colymboides* are shorter and heavier than others. There is also considerable variation in the position of the ridges in the region of the attachment of Mm. flexores perforati digiti II, III, and IV on the posterior surface of the femur. Milne-Edwards suggested that two species might be involved or that the observed differences might be sexual or individual. In the Common Loon, there is a considerable sexual difference in the length of the femur: those of 7 males and 11 females average 56.3 and 52.1 mm., respectively. This sexual difference is relatively greater than that found in any other limb element of the Common Loon. The coefficient of variation of 14 femurs (7 of males and 7 of females) of the Common Loon is 5.5 ± 1.0 ; that for 6 femurs of *Colymboides minutus*, 4.6 ± 1.3 . The latter figure, although a rather crude estimate owing to the smallness of the sample, does not suggest that we are dealing with more than one species of *Colymboides*. In the Common Loon, there is considerable variation in the size and location of the ridge marking the area of attachment of the Mm. flexores perforati digiti II, III, and IV, and this variation does not appear to be correlated with sex or age. On the basis of the condition in this Recent species, I believe that the differences in the size of the known femurs of *Colymboides minutus* are probably in part sexual, whereas those in the sculpturing of the posterior surface of the bone are individual in nature.

It must be pointed out, however, that the coefficient of variation for the lengths of 18 humeri of *Colymboides minutus* is very low, 2.0 ± 0.3 as compared with 4.2 ± 0.9 for 14 Common Loons (7 males and 7 females). This suggests a much greater degree of sexual difference in the femurs of *Colymboides* than was present in the humeri; in the Common Loon, this difference in degree of sexual variation between these two limb

elements is apparent though less marked. It is possible that this relatively great difference is correlated with corresponding sexual differences in the pelvis and synsacrum, but there is not enough material available at present to determine this.

Tibiotarsus (figs. 2 and 3).—In the degree of development of the cnemial process, this element of *Colymboides minutus* resembles the corresponding bone in grebes, but in characters which are more important from a phylogenetic standpoint it is loonlike. The lateral surface of the outer cnemial crest in the grebes is smooth and convexly rounded, and it is with this surface that the large patella articulates. In contrast, this surface of the outer cnemial crest of loons is concave and covered with a network of low ridges; the patella of loons, a minute splinter of bone, embedded in the tendons for the femorotibialis, pars externus, and the iliotibialis (Wilcox, 1952:543), does not articulate with the cnemial process. In *Colymboides*, the lateral surface of the outer crest is concave, as in the loons, and is roughened. There is no indication of an articulation with a patella. The general outline of the inner cnemial crest and the form of the posterior surface of the tibia, on which the ridge from the distal end of the outer cnemial crest continues distad beyond the fibular crest, are again loonlike as is the foramen through which the medullary artery emerges into a groove on the anterolateral part of the bone just distal from the fibular crest. In grebes this foramen is situated on a small ridge. The external ligamental prominence, the groove for the peroneus profundus, and the scar for the mesial end of the anterior ligament (Wilcox, 1952:547) all resemble the corresponding parts of the tibiotarsus of *Gavia* and differ from those of *Podiceps*.

The distal part of a tibiotarsus which Milne-Edwards (1867-1868, pl. 25, figs. 14-18) assigned with doubt to *Anas natator* may be that of *Colymboides*. However, it appears shorter; the distance from the distal end of the fibular crest to the distal end of the bone measures between 33.5 and 34.0 mm. on Milne-Edwards' figures 14 and 16, whereas this measurement on two specimens of *Colymboides* is 35.7 and 36.8 mm. It is difficult to assess the accuracy of these figures, and until direct comparisons with Milne-Edwards' material can be made, we cannot be certain that it is actually *Colymboides*.

In the original description of *Anas natator*, Milne-Edwards (1867-1868:148-149) failed to designate a type, although he stated that the existence of this species "was revealed to me by the discovery of an ulna of small size and perfectly preserved, which presented all the proper characters of the Anatidae; a short time later I collected from the same locality the distal end of a humerus and a nearly complete tibia, which perhaps belonged to this species" (my translation). This implies that he considered the ulna as the type. Because of this, because it is the only complete element, and because it is clearly that of a duck, I formally designate the ulna as the type of *Anas natator*. Thus, should the tibiotarsus prove referable to *Colymboides*, no change in the name of the duck will be necessary.

Tarsometatarsus (figs. 2 and 3).—In the museum in Basel Dr. Wetmore and I found three hitherto unidentified tarsometatarsi which we referred to *Colymboides*. I was able to find only two examples of this element in the material identified as *Colymboides minutus* in the Paris Museum, although it seemed odd to me that with all the other material of this species there should be so few tarsometatarsi. Later, on looking through Milne-Edwards (1867-1868), I noticed illustrations (pl. 57, figs. 18-22) of a bone which appeared to be identical with the tarsometatarsi of *Colymboides*. The bone illustrated was described by Milne-Edwards (pp. 362-364) as *Hydrornis natator*. After pointing out superficial resemblances between this bone and the corresponding elements of ducks and tubinares, Milne-Edwards concluded "I have preferred to adopt a name which does not indicate the zoological position of this fossil and its natural affinities because I find that they are not sufficiently known" (my translation).

Professor Jacques Berlioz very kindly compared one of the tarsometatarsi from the museum in Basel with the type and other material of *Hydrornis natator* in the Paris Museum. In a letter of April 7, 1956, he states

"I have been able, at the Laboratory of Paleontology, to make the comparisons you requested.

"It is certain that the bone (tarsometatarsus) which you have sent me is entirely similar to the type of *Hydrornis natator* Milne-Edwards. It even appears, from what is written on this bone, that it came from exactly the same lot of tarsometatarsi as the four others which are in our museum. (This is all which is catalogued under the name of *Hydrornis natator*.)

"I have also compared the more numerous bones catalogued as *Colymboides minutus* (tarsometatarsi, tibiae, coracoids, etc.), and there is scarcely any doubt that they belong to the same species of fossil bird, the differences between the tarsometatarsi being of the slightest and only individual. In addition, I must call to your attention that on the label of '*Hydrornis natator*,' a manuscript notation in pencil (but unsigned), apparently quite old, mentions: '*Hydrornis natator* = *Colymboides minutus*.'"

It is thus apparent that *Hydrornis natator* and *Colymboides minutus* are the same species. *C. minutus* was described from three different elements; *Hydrornis natator*, from only the tarsometatarsus. A second species, *anglicus*, has been described in *Colymboides*. *C. minutus* has page priority over *H. natator* and is the better known name. Therefore, as first revisor, I designate *Colymboides minutus* the name to be used. This will involve only one nomenclatural change, placing *Hydrornis natator* in the synonymy of *Colymboides minutus*; and in the unlikely event that page priority may again be used, no further change will be necessary.

Although more compressed laterally than this bone in ducks, the tarsometatarsus of *Colymboides* is much less compressed than that of Recent loons and resembles that of grebes in general proportions. Other characters in which this element of *Colymboides* differs from that of Recent loons are the much shallower grooves on the anterior and posterior surfaces of the bone and the lower calcaneal ridges, which do not meet in the midline (see fig. 3). In the evolution of Recent loons, the tarsometatarsus appears to have become more elongated than that of *Colymboides* in the region between the hypotarsus and the metatarsal facet. Aside from these differences, which are all attributable to a lesser degree of specialization for diving and swimming and are therefore primarily adaptive, the tarsometatarsus of *Colymboides* resembles that of Recent loons. It differs from the corresponding element of grebes in such fundamental characters as the arrangement of the canals through the hypotarsus and the conformation of the trochleae for the digits.

DISCUSSION

From the foregoing descriptions, it will be seen that *Colymboides minutus* was a small loon, some 10 to 12 inches in length. Its hind limbs were not as highly adapted for swimming rapidly and powerfully under water as are those of living loons. They had, instead, reached a level of adaptive development approaching those of a Pied-billed Grebe. Although their webbed feet were set far back on the body, these birds could probably walk somewhat better than grebes. Even so, their activities on land must have been quite limited, and they probably nested near the waters' edge as do living loons. Their relatively strong wings suggest that they flew more strongly and more frequently than their modern relatives, but I have found nothing in the structure of the wings to suggest that they were used under water like those of the alcids or diving petrels.

The diet of *Colymboides* was probably primarily animal, and its degree of adaptation for underwater swimming indicates that it could have captured small fish. It is unfortunate that the skull and bill of this bird are unknown.

The Aquitanian deposits of France from which *Colymboides minutus* comes are particularly rich in bird remains (Lambrecht, 1933). In spite of their antiquity, the species and genera of birds found in these deposits are similar enough to living forms to permit us to draw some general conclusions concerning the climatic and ecological conditions under which these birds lived. That the climate was warm is suggested by the presence of a trogon (*Paratrogon*), a parrot (*Archaeopsittacus*), a crowned crane (*Probalearica*), a secretary bird (*Amphiserpentarius*), six flamingos (*Phoenicopterus croizeti*) and five species of the primitive, straight-billed group known as *Palaelodus*), and five genera of storks and ibises. The presence of the flamingos, the storks and ibises, at least two dabbling ducks (*Anas blanchardi* and *A. consobrina*), two cranes (*Probalearica* and *Palaeogrus*), two rails (*Palaeoaramides* and *Paraortygometra*), five genera of shorebirds (three scolopacids, a thick-knee, and a stilt), and three small gulls (*Larus elegans*, *L. desnoyersi*, and *L. totanoides*) indicate the presence of marshes and mud flats. Two marine forms, a shearwater (*Puffinus arvernensis*) and a gannet (*Sula arvernensis*), suggest a coastal situation. Other groups of birds represented include a pelican, two cormorants, a heron, a kite, two small eagles, a vulture, several partridges, a small dove, a sandgrouse, three owls, two swifts, two woodpeckers, a hoopoe-like bird, and at least three passerines.

The problems raised by the study of *Colymboides minutus* alone are proof enough that this remarkable fauna needs to be studied in greater detail. Until such monographic study can be made and the taxonomic positions of all the species determined with greater precision, it is probably not safe to conclude more about the conditions under which these birds lived than I have outlined.

It is evident that *Colymboides minutus* was a primitive loon. Having established this, it should be possible to shed new light on the ancestry of the loons and their relationship to other groups of birds. Two lines of reasoning might be used to do this: it might be possible to work back from their present habits and adaptations through *Colymboides* to a hypothetical ancestor, or it might be possible to find which other groups share relatively non-adaptive morphological characters with the loons. Further, each method might also be used as a check on the other.

If we assume that the resemblances between loons and grebes are the results of convergent evolution, then the most striking morphological differences between them may be considered oldest from a phylogenetic standpoint. Some of these old, "non-adaptive" characters in loons (including *Colymboides*) are the form of the coracoid, the expanded carpal tuberosity on the ulna, the two tendinal grooves near the distal end of the radius, the elongated first metacarpal, and the two proximal foramina and the arrangement of the tendinal canals on the hypotarsus. To begin with, these characters were looked for in representative examples of the grebes, tubinares, steganopodes, herons, ibises, flamingoes, ducks, galliformes, gruiformes, and charadriiformes. The arrangement of tendinal grooves near the distal end of the radius is not shared by any other group examined, although the alcids have two such grooves. In most of the groups studied, the carpal tuberosity on the ulna is developed but not similar to that of the loons in form, and most groups agree in having two proximal foramina on the tarsometatarsus. The grebes, tubinares, steganopodes, and galliformes share none of the other characters with the loons. This is particularly interesting in view of Mayr and Amadon's unsupported statement (1951:5) on the position of the loons. "Since, however, the grebes have been thought to be remote allies of the petrels, and since McDowell (oral communication)

thinks that loons may be a specialized offshoot of petrel stock, it is possible that the grebes and loons have some distant or indirect relationship."

The shaft of the coracoid of *Colymboides anglicus* (fig. 4) is narrower than that of *C. minutus*. This suggests that the ancestors of the loons had even narrower coracoids. In contrast, the coracoid of *Puffinus*, a genus which goes back to Aquitanian times, is even shorter and broader than that of Recent loons. The coracoids of the tubinares in general also differ from those of the loons in the more proximal position of the coracoidal fenestra and the conformation of the sternal end of the bone. The tubinares also differ in having three proximal foramina on the tarsometatarsus and two tendinal canals in the anteriormost row on the hypotarsus. These, plus the entirely different structure of the wing bones in the tubinares, admittedly highly modified for soaring flight, preclude close relationship.

The coracoid of loons is most similar to that of shorebirds and gulls, and birds of these groups also have two proximal foramina on the tarsometatarsus and three anterior hypotarsal canals. Thus, the loons may have their closest relationship with the great charadriiform complex. However, the loons constitute an old and well-marked group, and their affinities are still by no means certain.

The evolutionary history of the loons may be reconstructed thus: In some period between the late Cretaceous and the early Eocene, loons became separated from a very primitive larine stock and evolved the diving habit. The coracoid of *Colymboides anglicus* of the late Eocene is sufficiently similar to that of *C. minutus* for us to infer that, like the latter species, it was a foot-propelled diving bird. There is a gap in the fossil record from the late Eocene to Aquitanian times (late Oligocene or early Miocene) when *Colymboides minutus* was found. By this time, loons had reached a level of specialization for diving equivalent to that of the Pied-billed Grebe. *Gaviella pusilla*, provisionally assigned by Wetmore (1940) to the White River formation (Oligocene), does not appear to be closely related to either *Colymboides* or to modern loons, and as it is known from only a fragmentary carpometacarpus, it is not possible to make inferences about its diving ability. No other fossil loons are known from deposits earlier than those of the Pliocene, in which four species of the modern genus *Gavia* (*G. concinna*, *G. howardae*, *G. palaeodytes*, and *G. portisi*) occurred (Brodkorb, 1953). Two Recent species, the Common Loon (*G. immer*) and the Red-throated Loon (*G. stellata*), are known from deposits of Pleistocene age.

Finally, the question of the taxonomic position of *Colymboides* within the order Gaviiformes must be considered. The morphological differences between *Colymboides* and *Gavia* are many and rather great, but they are largely ones of size and of degree of specialization. With the present gaps in the fossil record, it would be unwise to state dogmatically that *Colymboides* was ancestral to *Gavia*, but I think that it must at least have been near the ancestral stock of modern loons. If we had a series of intermediate forms linking *Colymboides* and *Gavia*, all would be considered part of a single subfamily. Thus, until we have strong evidence to the contrary, I believe that *Colymboides* should be placed in the Gaviinae.

The loons should be classified as follows:

- Order Gaviiformes
 - Family Gaviidae
 - Subfamily Gaviinae
 - Genus *Colymboides*
 - Genus *Gavia*
 - Subfamily Gaviellinae
 - Genus *Gaviella*

SUMMARY

Colymboides minutus, from Aquitainian deposits (late Oligocene or early Miocene in age), was a primitive loon. Its resemblance to the grebes results from its having reached an adaptive level comparable to that of the grebes.

Hydrornis natator is a synonym of *Colymboides minutus*.

The loons and the grebes did not have a common swimming ancestor. The loons appear to be distantly related to the Charadriiformes.

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FORAGING HABITS AND LOCAL MOVEMENTS OF THE WOOD IBIS IN SAN DIEGO COUNTY, CALIFORNIA

By ANDREAS B. RECHNITZER

Published records and personal observations indicate that each summer a few Wood Ibises (*Mycteria americana*) visit southern California, particularly the Imperial Valley marshes, Imperial County, and the coastal lagoons of San Diego County. Occasional stragglers have been recorded farther north: Long Beach (Law, 1912); Bixby, Los Angeles County (Daggett, 1903); San Bernardino Valley (Feudge, 1903); Daggett, San Bernardino County (Lamb, 1912); Santa Barbara (Rett, 1954); San Francisco Bay (Cooper, 1887). These annual migrants which are thought to come from the coast of western Mexico, where the species is common, appear in late June or early July and depart by mid-October. The numbers recorded vary considerably from year to year as shown in table 1. Except for the years from 1953 to 1955, when a definite effort was made to locate all individuals within the limits of San Diego County, it is suspected that the recorded numbers are underestimates of the numbers present in the county. Surveys made weekly or biweekly in the summers from 1953 to 1955 showed that the Lt. Maxton Brown Sanctuary (Buena Vista Lagoon), between Oceanside and Carlsbad, is the major foraging area for the Wood Ibis. The Santa Marguerita River mouth, north of Oceanside, and the San Elijo Lagoon at Cardiff are used as foraging areas to a lesser extent. The other lagoons and bays shown in figure 1 are now used only very infrequently. All of these areas have been occupied in the past (Lawrence Huey, personal communication), but probably they have been rendered unsuitable by dredging, filling, and sewage disposal. No Wood Ibises have been recorded recently for lakes Sutherland, Henshaw, Sweetwater, El Capitan, Lower Otay, Hodges, Wohlford, and San Vicente, and none had been observed at these lakes by representatives of the Department of Fish and Game whom I questioned. This is of interest because these lakes would seem to be logical "stop-over" areas if the birds observed in the coastal lagoons come from the Imperial Valley marshes.

Audubon (1835:129) described the rather spectacular feeding and flight habits which are characteristic of the species:

"To procure its food, the Wood Ibis walks through shallow muddy lakes or bayous in numbers. As soon as they have discovered a place abounding in fish, they dance as it were all through it, until the water becomes thick with the mud stirred from the bottom by their feet. The fishes, on rising to the surface, are instantly struck by the beaks of the Ibises, . . . [and], on being deprived of life, they turn over and so remain. In the course of ten or fifteen minutes, hundreds of fishes, frogs, young alligators, and water-snakes cover the surface, and the birds greedily swallow them until they are completely gorged, after which they walk to the nearest margins, place themselves in long rows, with their breasts all turned toward the sun, in the manner of Pelicans and Vultures, and thus remain for an hour or so. When digestion is partially accomplished, they all take to wing, rise in special circlings to an immense height and sail about for an hour or more, performing the most beautiful evolutions that can well be conceived."

Daggett (1903) examined the full crop contents of one bird taken at Bixby, California and found only aquatic insects. Grinnell, Bryant, and Storer (1918) listed the stomach contents of three Wood Ibises taken in Imperial County, California. One contained 3 tadpoles, 4 water beetles, 2 paddle bugs, and some moss [algae?]; another, 9 tadpoles, a water beetle, 9 dragon fly larvae, and a carp; the third held 10 carp, a catfish, 2 bony tails [*Gila robusta*], and a water cricket. Bryant (1919) reported

on another bird with 10 seeds of the screw bean, 2 seeds of mesquite, parts of 4 water beetles and some finely comminuted vegetable material. Holt and Sutton (1926) recorded the stomach contents of some adult birds collected at Alligator Lake, Florida. They found small fishes, reported as *Mollienisia latipinna*, *Cyprinodon variegatus*, *Gambusia affinis*, *Lepomis holbrooki*, and *Adinia multifasciata*, to be present.

Because conditions for observation in the San Diego lagoons are particularly favorable, it has been possible in the present study to identify larger items of food without

Table 1
Maximum Number of Wood Ibises Observed in San Diego County

Year	Number of ibises	Reference ¹
1946	150+	Audubon Field Notes, 1947, 1:20.
1947	22	Audubon Field Notes, 1948, 1:23.
1948	8	Personal observations.
1949	2	Audubon Field Notes, 1950, 1:34.
1950	2	Audubon Field Notes, 1951, 1:38.
1951	70	Personal observations.
1952	57	Audubon Field Notes, 1953, 1:36.
1953	300+	Personal observations.
1954	36	Personal observations.
1955	71	Personal observations.

¹ Published sight records and my personal observations agree closely for all years concerned. Personal observations are entered for those years wherein my cumulative total for a single day's survey indicated more birds or represented a more synoptic observation.

sacrificing birds. In the limited and confined marsh channels of San Elijo Lagoon the major constituent of the diet is a fish, the topsmelt *Atherinops affinis littoralis*. As the Wood Ibis is a rather indiscriminant fish-eater, it is possible that it takes other fish inhabitants of these channels, namely the California killifish, *Fundulus p. parvipinnis*; tidewater goby, *Eucyclogobius newberryi*; arrow goby, *Clevelandia ios*; longjaw mud-sucker, *Gillichthys mirabilis*; and probably the shadow goby, *Quietula y-cauda*. Carcasses of all those fishes, except the shadow goby, were found along the banks of the watercourses following a feeding foray by the ibis. In the freshwater San Dieguito Reservoir near Rancho Santa Fe, Wood Ibises were observed eating young black bass, *Micropterus salmoides*, and catfish, *Ictalurus* sp.

Ordinarily the birds were observed to eat their catch immediately after capture, but toward the end of a feeding period they began to appear satiated and would, at times, release their victims although continuing to hunt in the company of the flock with seemingly the same diligence and enthusiasm. On one occasion several thousand decaying carcasses of the topsmelt, killifish, and gobies were found in a single winddrift in the San Elijo Lagoon. Scarred and mutilated bodies suggested that they were victims of ibises, which were observed feeding in the immediate area on the previous day. Live schools of fish still remained in the area at the time of this observation, indicating that the mass mortality was probably not due to other adverse causes.

In feeding, the ibises cooperate by walking in groups, often abreast, or nearly so, through the narrow meandering drainage channels of the marshes. This method effectively extends the ranks of a flock across the entire channel width, which seldom exceeds 30 feet. At times the "marching" group is two or more birds deep. They usually start their feeding forays near the mouth of a channel or at the junction of two channels. From this point the ibises walk slowly and deliberately toward the shallow and nar-

rowing origin. The casual, non-stalking gait of the ibises effectively muddies the water, but it is doubtful that this is a necessary preliminary to catching prey in water that is already roiled or continually turbid. This foot and leg movement disturbs the water enough to herd the schooling-type fishes into shallow and more restricted areas where they are then killed and taken in large numbers. The use of foot activity for feeding may also serve to direct swimming prey animals to the beak (Rand, 1956).

Foraging in the more open waters of the San Dieguito Reservoir or the Lt. Maxton Brown Sanctuary is performed in a comparable manner, the birds working the shallows of these areas in groups of 20 or more.

When feeding in groups, the Wood Ibises do not dart the head at their prey but instead employ a groping method. With the head turned to the side, the partly open beak is immersed in water to a depth of several inches and is then passed through the water sideways like a pair of tongs. Movement of the beak through the water is accomplished either by swinging the head in a semicircular arc or by walking forward with the head turned to the right or left. When contact with a fish is made, the beak is snapped shut and invariably the bird is successful in securing a squirming morsel. It appears that the tactile sensitivity of either the tongue or the tissue lining the inner surface of the bill is remarkably developed to permit such effective feeding under relatively adverse conditions. When birds feed singly, they resort to a visual technique and take their prey by stalking and darting with the bill.

The feeding periods are usually from pre-dawn to about three hours after sunrise and for a comparable period prior to and following sunset. After feeding, the birds usually retire to dry ground near the last feeding site, where they remain during the daylight hours. Birds separated from the flock sometimes continue to feed for longer periods. After feeding, short sortie flights are made to re-establish the flock. In the early summer, shortly after their arrival, they are very gregarious and all post-feeding resting is done as a unit. Dispersal, however, becomes more common later in the season, particularly during the month of September.

Although the feeding activities of the Wood Ibises produced a surplus of fish, no other birds were noted associating with them at this time. It was particularly noticeable that the gulls (*Larus heermanni* and *L. californicus*) which were fishing at other points in the lagoon stayed away from the Wood Ibis and did not serve as a "clean-up" detail for the fish left to spoil. The Great Blue Herons (*Ardea herodias*), American Egrets (*Casmerodius albus*), Snowy Egrets (*Egretta thula*), Black-necked Stilts (*Himantopus mexicanus*) and terns (*Sterna antillarum* and *Thalasseus maximus*) which were present in the lagoons also seemed to avoid the immediate vicinity of the ibis.

Following the partial digestion of a meal the ibis reportedly takes to the air to soar (Audubon, 1835). Here again the behavior of the Wood Ibises as observed in southern California does not follow the described pattern. The short flights made by the summer visitors have been mentioned above, but the more spectacular soaring flights have been restricted almost entirely to the end of the summer. Soaring in gyres the ibises rise to heights that require binoculars to keep them in sight. On overcast days, they often disappear into the cloud cover. I have observed the spectacular plummeting dive from these high altitude flights only once (Rechnitzer, 1954). Following these flights the birds were not observed to return to the lagoon, indicating that they probably continued over the coastal range, either into the Imperial Valley or to the Gulf of California.

Dawn and dusk flights were a conspicuous part of the daily activities prior to the 1955 visit. Throughout previous summers the ibises regularly vacated San Elijo Lagoon at dusk and flew to the drainage area of the San Dieguito River (air distance about two miles). The flock usually rose into the air in tandem, and staggered their numbers so

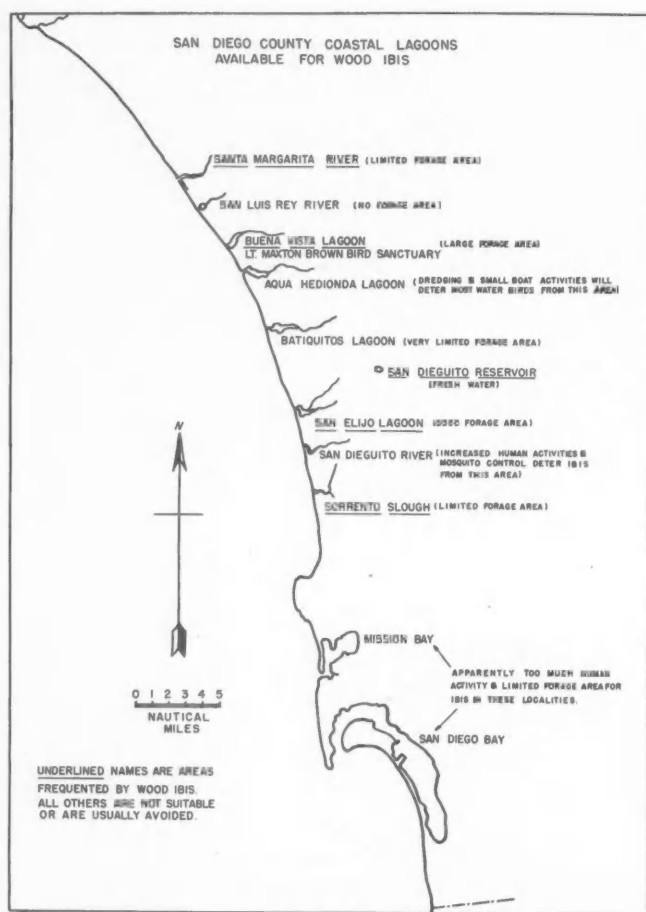


Fig. 1. Principal marsh and lagoon areas of San Diego County, California. Only San Elijo and Buena Vista lagoons, and the mouth of the Santa Marguerita River continue to attract Wood Ibises.

that the procession was intermittent but confined to a relatively short period of each day, once near sunset and again on the following morning for the return flight. The birds gained only enough altitude to permit short glides and to pass over the low ridge of hills adjacent to the lagoon. No flights other than these intra- and inter-lagoon flights were noted. In 1955 the inter-lagoon flights were completely interrupted. An increase in aircraft activities, coupled with a heavy application of a strong insecticide to the impounded waters of the lower San Dieguito drainage area probably discouraged the birds from this former summer habitat. All of the Wood Ibises remained within the San Elijo Lagoon until July 28, 1955. At this time they were frightened out of the marsh area by a "con-

trolled brush fire," which engulfed all of the watercourse with dense smoke and destroyed the lush stand of the marsh weed *Salicornia* that blanketed the exposed areas of the lagoon. Subsequent visits to the lagoon revealed a complete exodus of Wood Ibises until early October, when the southward migration began. At this later time the birds stayed in the lagoon for only a single day or less.

After the abandonment of San Elijo Lagoon on July 28, 1955, a group of 48 birds temporarily relocated in the San Dieguito Reservoir, which is situated inland about five miles from the lagoon and relatively close to the main drainage channel that feeds the lagoon during the winter run-off (if any). After three weeks the reservoir was devoid of ibises. The number of birds in the Lt. Maxton Brown Sanctuary and the Santa Marguerita River mouth had, at this time, attained a cumulative total comparable to that observed earlier in the season at the more southerly San Elijo Lagoon.

Photographs of Wood Ibis in Florida (Bent, 1926) indicate their preference for tall trees as roosting sites. Although all the areas visited in San Diego County have trees nearby, I have yet to see a Wood Ibis occupy the apparently suitable trees, while the Great Blue Heron, American Egret, and Snowy Egret often rest in tall eucalyptus trees.

Each fall the ibises begin to move south gradually when there is a drop in the night temperatures. The daytime temperatures remain fairly high, and that there is an apparent reluctance in this movement southward, is evidenced by the occupation of the marsh or lagoon next to the south for a day or two before the ibises move on. Most of the birds leave the coastal lagoons of San Diego County after reaching San Elijo Lagoon, but a few stop four miles to the south, temporarily, at Sorrento Slough.

SUMMARY

Wood Ibises continue to visit southern California coastal lagoons as summer migrants, probably from the west coast of Mexico. They are conspicuous among the aquatic birds because of their size and their white plumage, and because of the general paucity of vegetation and obstructions in the marsh areas visited. The Wood Ibis, despite the awkward appearance of its large bill, is a very efficient feeder, particularly on small fishes and aquatic insects. The beak is immersed several inches into the turbid water and held agape while being passed to and fro like a large pair of forceps. Upon contact with a fish the bill is snapped shut. The ibises feed in flocks of 20 or more, which permits them to span the narrow drainage channels of the lagoons and thereby effectively to herd the fish into shallow water. Flight activities are not a conspicuous part of their behavior while in southern California, but soaring to great heights has been observed toward the end of summer. The amount of available forage space is being reduced by urban development along the coast, and only one sanctuary area remains as the principal area visited by Wood Ibises.

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ANATOMICAL VARIATION AND AVIAN ANATOMY

By ANDREW J. BERGER

Fisher (1955:69) called attention to the urgent need for more information on the amount of morphological variability "in a homogeneous series within a species." Fisher and Goodman (1955:119), in a thorough investigation of the myology of the Whooping Crane (*Grus americana*), were impressed by "the great variability that may exist in the conformation of muscles and, apparently, in the pathways of nerves to the muscles," and by the fact that "the extent of variation [in the brachial plexus] between individuals is of no greater scope than that . . . between the sides of an individual."

It seems desirable, therefore, to examine anatomical variation in general, with special reference to its bearing on the phylogeny of birds. Under four headings—neurology, myology, osteology, and angiology—I propose to point out certain basic concepts or principles derived from the accumulated morphological knowledge of the best-known mammal, man, and to include information on variation in birds.

Morphological variation is, of course, the rule, not the exception. This is one of the first things to be learned by the beginning student of human anatomy. Although there is a basic typical design for each vertebrate class, or order, or family, no two animals, however closely related, have exactly the same conformation in the minute structure of all organ systems. One cannot by knowing the pattern on one side of a body predict the pattern on the opposite side, although one might predict that they would be the same in a certain percentage of cases. In order to make such a prediction, however, one needs a mass of data obtained from hundreds of dissections, which enable one to visualize clearly the normal limits of variation. Consequently, it should be emphasized at the start that the particular pattern on one side of a body need exhibit no more similarity to the pattern on the opposite side than to the pattern in some other body. Ornithologists should not be surprised, therefore, when it is pointed out that the pattern of the brachial plexus or the vascular system differs in the two wings or two legs of one specimen.

NEUROLOGY

For the present purpose, we need discuss only the brachial plexus and some of its terminal branches. A plexus is a "network or tangle, chiefly of veins or nerves" (Dorland, 1945:1146). Specifically, the brachial plexus is a network by which the nerve components associated with certain spinal nerves are rearranged. It has a general, but not invariable, pattern characteristic for each group of animals. In man the brachial plexus is typically formed from the anterior primary rami of the last four cervical spinal nerves (nos. 5–8) and the first thoracic spinal nerve, but in many cases (62 per cent of 175 plexuses in one study) the plexus receives contributions from the fourth cervical nerve; it often receives small twigs from the second thoracic nerve as well. Furthermore, the entire plexus may be shifted a segment cephalad or caudad, in which event the plexus is said to be prefixed or postfixed, respectively (see Kerr, 1918). There is also considerable variation in the gross pattern of this plexus when it is formed from the usual spinal nerves.

Now with respect to the terminal branches of the brachial plexus, *M. teres major*, in man, is innervated by the lower subscapular nerve. This nerve typically is a separate branch of the posterior cord of the brachial plexus, but not infrequently it arises by a common trunk either with the thoracodorsal nerve or the axillary nerve. Again, the musculocutaneous nerve, arising from the lateral cord of the plexus, innervates the preaxial muscles of the arm and then terminates as a cutaneous nerve. This nerve typically pierces *M. coracobrachialis*, innervates it, and then passes distad in the interval

between Mm. biceps brachii and brachialis, sending branches to them. But the musculocutaneous nerve does not always pierce the coracobrachialis muscle. That muscle may receive a branch(es) from the nerve, or a separate, more proximal, branch directly from the lateral cord. In the latter case, the definitive musculocutaneous nerve simply passes along the coracobrachialis muscle without sending branches to it. In some bodies, the musculocutaneous nerve sends, at a variable level, a ramus to join the median nerve, a nerve which innervates no muscles in the arm and gives off no branches there. The median nerve itself is formed by the union of rami derived from the medial and lateral cords of the brachial plexus, but the site of union may be located at any level from the axilla almost to the elbow.

All of these and other differences from the "typical" pattern are considered to fall within the normal limits of variation. They are not pathological, and they do not interfere with the functioning of the muscles innervated. Considering these differences to represent normal variation, how can one interpret or explain such variation from a genetically established plan? Up to a point, the explanation is relatively simple. What is spoken of grossly as a "nerve" is actually a structure composed of hundreds of nerve fibers arranged in bundles or funiculi held together and surrounded by connective tissue. The nerve cell bodies of the neurons whose axons form the motor components of the median nerve are located in the ventral horn gray of the sixth, seventh, and eighth (sometimes also the fifth) cervical and the first thoracic segments of the spinal cord. Assuming, within limits, nerve-muscle specificity between nerve-cell columns in the spinal cord and certain muscle groups, it matters little what course or path the axons follow to reach those muscles. All that is necessary is that the axons do reach them—this is one of the key problems in effecting a successful re-innervation of a muscle after its motor supply has been cut. Thus, the ramus of the musculocutaneous nerve which joins the median nerve in the lower arm contains axons derived from the median nerve portion of the motor cell column in the spinal cord. Those neurons are not destined to innervate pre-axial muscles of the arm and, therefore, sooner or later, they rejoin the median nerve in order to reach their proper termination. It seems reasonable to expect similar variations in the gross pattern of the definitive nerves from the bird brachial plexus. We should, indeed, be surprised if such variation were not found.

Even though we may assume that the gross pattern of the brachial plexus has a genetic basis, such variations as those discussed above do not cast doubt on the phylogenetic relationships of individuals of *Homo sapiens*. One should not, therefore, place undue emphasis on such variation in birds. The gross pattern of the brachial plexus *per se* reveals very little about the ultimate innervation of the muscles. Not until localization of the cell columns in the spinal cords has been determined (by means of neuron chromatolysis experiments), will much really be known about the innervation of the appendicular muscles of birds. Furthermore, it is scientifically naive to assume that the gross nerve supply of a muscle is the same in all genera or families of birds. Hence, it would be uncritical when discussing the myology, but not the neurology, of cuckoos, for example, to cite from Fisher (1946) the innervation of the muscles as he found it in the vultures. What justification is there for quoting from the few workers (Fürbringer, Gadow, Howell, Fisher) who have studied the innervation of avian muscles? Such reference has meaning when one compares published data with original data on the same or another group of birds, or when one presents a compilation which attempts to summarize nerve-muscle relationships in birds. Even then, the limitations inherent in dealing only with gross patterns must be recognized.

Nevertheless, we do need to know much more about the gross relationships between muscles and nerves in birds. There is, relatively, so little known about the total appen-

dicular myology of birds, however, that the new student of avian anatomy should not be distracted by a pedantic concern with the homology of muscles outside the class Aves.

MYOLOGY

In general, the muscular system is more stable than the nervous or vascular systems. One frequently encounters difficulties in attempting to generalize, but it might be said that, in man, more variation is to be expected in the distal muscles of the extremities, or in muscles having an extensive origin, such as *M. pectoralis major*, than in more proximally located muscles or those having a small, discrete origin, such as the long head of *M. biceps brachii*. There are, of course, exceptions to such a broad statement. The fact is, however, that variations in the configuration of muscles are relatively frequent, but mostly minor in nature. Small accessory heads, bellies, or tendons of the forearm muscles are common in man, but their presence does not complicate the interpretation of the musculature of that region. In rare instances, a muscle such as the *coracobrachialis* or *biceps brachii* may be absent. Such variations from the usual pattern are spoken of as anomalies. One would not in view of even the complete absence of a muscle contemplate assigning the individual to a different species or genus. In man, the anomaly can be recognized as such because the total myology of the human body is so well known.

We do not know that much about avian anatomy. We know, in fact, very little about intraspecific variation in the myology of birds. Therein lies the great need for many detailed studies of avian myology. Careful dissections, with accompanying detailed descriptions and measurements, of all of the appendicular muscles in 200 or 300 individuals of a given species would undoubtedly reveal many interesting facts. Until such data are available, the anatomist has no choice but to record details and interpret them in the light of his experience. The most interesting and significant taxonomic problems in avian anatomy frequently involve "aberrant" genera of which one is fortunate to obtain even two adequately preserved alcoholic specimens. Moreover, if one attempts a critical analysis of the muscles of any given group of birds, one soon discovers that all too little is known about the configuration and relative development of individual muscles in the various families and orders of birds. I decided several years ago that I could not interpret adequately data on the myology of the Cuculidae until I knew more about the nature of certain muscles and muscle-groups in other orders.

The following are examples of variation in bird muscles. Fisher and Goodman (1955:120) found that "in three of our six dissections of the Whooping Crane, *M. pectoralis* utilized the well developed tracheal enclosure for part of its origin." They noted also that *M. latissimus dorsi metapatagialis* is variable in development and may be absent and that the belly of *M. flexor perforans et perforatus digiti II* may or may not be bipennate. Hudson and Lanzillotti (1955:39) found *M. flexor pollicis* in only two crow wings "out of 22 wings of the crow and six of the raven," and (pp. 34-35) they found a unilateral variation of *M. extensor indicis longus* in *Cyanocorax*: "on the left side the origin is from the radius only, as usual, but on the right side there is a distinct extra head of origin from the ulna. In one specimen of *Aphelocoma coerulescens californica* both sides have an ulnar attachment." Fürbringer (1902:536) noted the absence of *M. deltoideus minor*, perhaps as an individual variation, in *Cypselus*. Beddard (1898:309) stated that *M. latissimus dorsi, pars posterior*, is sometimes absent in pigeons and that, according to Fürbringer, "its occasional absence is a matter of individual variation."

More is known about individual variation in the *ambiens* muscle, probably because it is one of the "formulae" muscles and, therefore, has been studied more intensively. This muscle is present in some genera of parrots, absent in others. "*Stringops* is peculiar in that the muscle is sometimes complete and quite normally developed, and sometimes

ends in a thin tendon on the capsule of the knee joint. This recalls *Oedictes*" (Beddard, 1898:261). Similar variations have been reported in *Opisthocomus*, *Phaethon* and some of the *Procellariiformes* (Beddard, 1898:289, 405, 448).

Fisher and Goodman (1955:85, 123) emphasized the amount of variation they found in *M. caudofemoralis* (*piriformis*) in three specimens of the Whooping Crane, and they discussed other differences in the muscle formulae of cranes found by the several investigators of that group. Their report is especially significant because the two parts of *M. caudofemoralis* are widely used in the muscle formulae of Garrod. Both parts (*pars caudofemoralis* and *pars iliofemoralis*) of this muscle were found in two specimens of the Whooping Crane, but only *pars iliofemoralis* in a third specimen. In one dissection, they found three parts to the muscle. I found both parts of this muscle in three specimens of the Sandhill Crane (*Grus canadensis tabida*).

A basic question is involved here. Several anatomists in recent years have emphasized the necessity for knowing the complete appendicular myology of birds and not just the leg-muscle formulae. These formulae are convenient items to tack on to the technical diagnoses of families and orders of birds and all standard references give credence to this amount of myological data. Beddard's (1898:367) brief report on variation in the muscle formulae in the *Gruidae* should have cast doubt on the validity of these muscles for solving taxonomic problems. Fisher and Goodman (1955:124) stated: "Thus it is impossible with the information at hand to set up any definite formula for the family *Gruidae*, or apparently even for the genera *Grus* and *Balearica* as now known. One would not expect intraspecific variation of the sort we noted or that found by Mitchell and Beddard in *Balearica* The variation of *G. leucogeranus* from the *Grus* line is not unexpected, for this crane also differs in many other ways." If, however, leg muscle formulae were as diagnostic as they were thought to be, these differences would not be found. As far as these muscles are concerned, it is possible that the cranes present one of the more troublesome groups. One would not, as Fisher and Goodman stated, expect this amount of intraspecific (or intrageneric) variation in a muscle complex unless it were in the process of "dropping-out" phylogenetically, in which case one might expect considerable variation. How much of this variation in the cranes falls under the heading of anomaly? One would surmise that the "normal" or "typical" pattern for the genus *Grus* is the presence of both parts of *M. caudofemoralis*. At the same time, certain features in the development of *pars caudofemoralis* suggest that it might be in the process of becoming vestigial in certain groups of birds. In a bird the size of the Sandhill Crane, for example, the belly of *pars caudofemoralis* is only 9 cm. long and has a maximum width of less than 1 cm.; the tendon of origin is but 0.5 mm. in diameter. Relative to its development in some other birds, *pars caudofemoralis* might be considered rudimentary in the cranes. The relatively small size of the muscle in some genera, however, may be only a reflection of locomotor habits.

The absence of a given muscle in a single specimen of a species or genus does not necessarily mean, however, that that muscle is not characteristic for the species or the genus or that the muscle is useless as a taxonomic character, either for that group or for other groups. After one dissects a number of closely related genera, one quickly recognizes deviations from the typical pattern. One must realize that one may be dealing with an anomaly, a situation which does not negate all of the other evidence.

One other point of variation in the cranes deserves mention. Gadow and Selenka (1891:142) and Hudson (1937:60, 69) reported that they did not find *M. iliiochantericus medius* in the genus *Grus*, but Fisher and Goodman (1955:123) found it in *G. americana* and *G. canadensis*. I found this muscle bilaterally in two specimens and unilaterally in a third specimen of *G. canadensis tabida*. In each of my dissections, however,

there was evident fusion between *Mm. iliотrochantericus medius* and anterior; the two muscles were separate at their origins, but the bellies fused distally to insert by a common tendon. In the right hip of the one specimen, the two muscles were completely fused, so that this complex was represented by a single muscle mass, arising, however, from the same area as that occupied by both muscles in the other dissections. Such fusion is not rare phylogenetically when two muscles arise or insert on adjacent areas and when their fibers have a generally parallel course. One may also recall both the phylogenetic and the ontogenetic differentiation of separate muscles from primitive muscle masses.

Thus it is clear that much needs to be known not only about intraspecific variation of muscles, but also about the presence or absence and the relative development of the appendicular muscles throughout the families and orders of birds. Relative development is not indicated by a simple muscle formula. No region has received adequate attention throughout the orders of birds. The excellent series of papers on the head (Barnikol, 1952, 1953*a*, 1953*b*; Hofer, 1950; Starck and Barnikol, 1954) serves to emphasize the need for additional comparative studies.

OSTEOLOGY

Less tedious than myology, the osteology of birds has received more attention. More adequate series of skeletons are available than of alcoholic specimens, although articulated skeletons are all too rare in many collections. The difficulties encountered in dealing with inadequate series of skeletons were well expressed by Lucas (1893:52): "Unfortunately the problem is rendered all the more difficult from the fact that the large series of specimens necessary for its solution are seldom available, so that characters may be considered of specific value, or . . . as mere abnormalities, when they are really normal variations, or perhaps, due to changes brought about by age." One needs, then, a reasonably large series of skeletons in order to determine the typical pattern of bony elements. Variation is found in all species of birds; it should be expected.

Shufeldt (1888:326) commented briefly on variation in the number of cervicodorsal ribs and Berger (1952:518; 1955*a*:587) on their uncinat processes. Lucas (1888, 1889, 1893) cited examples of variation in the numbers of true ribs. He stated (1888:52-53) that extra ribs are "not uncommon," but that "any lessening of the normal number is very rare and only once has such a case come under my notice," a Catbird (*Dumetella carolinensis*), in which the true ribs were reduced to five. Fisher (1946:562) discussed variation in the fenestration of the posterior margin of the sternum and stated that "in *Cathartes* the individual differences in fenestration are manifold."

In spite of the fact that Shufeldt and other earlier workers stated unequivocally, at times, that the several regions of the vertebral column contained a specific invariable number of vertebrae, Berger (1952, 1953, 1954, 1955*a*) presented evidence to the contrary. The number of cervical and dorsal vertebrae is relatively constant within cuculine genera. *Geococcyx*, *Crotophaga*, and *Chrysococcyx* (including "*Chalcites*" and "*Lampromorphus*") have 14 cervical vertebrae; to date I have found no variation in these genera. Thirty out of 31 specimens of the genus *Coccyzus* had 13 cervical vertebrae (contrary to the report by Shufeldt that this genus has 14), whereas the other specimen had 14 cervical vertebrae, certainly an anomalous number for this genus (see Berger, 1954:8-9). Of ten cuculine genera I have investigated thus far, I have seen only one example of variation in the number of dorsal ("thoracic" of some authors, but see Newton, 1896:849) vertebrae. The *Chrysococcyx* complex normally has four dorsal vertebrae. "One alcoholic specimen of *Chrysococcyx cupreus*, however, has five dorsal vertebrae and five dorsal, or true, ribs. Of the latter, four articulate with the sternum, while the fifth fuses ventrally with the fourth rib; there is no thoracic rib" (Berger, 1955*a*:

587). When the normal number of four dorsal vertebrae is present, there is also a thoracic rib. On the other hand, variation is common in the number of ribs which articulate directly with the sternum. With a total of 14 alcoholic and skeletal specimens for study, the following variation was found. "Four, apparently, is the 'normal' number of sternal ribs in these species. In one specimen of *Chrysococcyx cupreus* and two specimens of *Lampropromorpha caprius*, however, only three of the four dorsal ribs articulate directly with the sternum; and in an alcoholic specimen of *L. klaas* three ribs articulate with the sternum on the left side, whereas four do so on the right" (Berger, *loc. cit.*).

I recently examined 14 skeletons representing six genera and nine species of Plantain-eaters (Musophagidae). All except one had five dorsal vertebrae; one skeleton of *Turacus persa* (USNM No. 291,319) had but four dorsal vertebrae.

Two other regions of the vertebral column, however, exhibit considerable variation in the numbers of included vertebrae: the synsacrum and the free caudal vertebrae. Counting the fused vertebrae in the adult synsacrum is, at times, a difficult task. Moreover, no author, apparently, has told how he counted the individual vertebrae in the synsacrum; it is possible to count them in at least two ways so that one obtains two different answers. There is no doubt, however, that variation does occur. The following data are an example of such variation.

No. of fused vertebrae in synsacrum	Number of specimens			
	<i>americanus</i>	<i>Coccyzus erythrophthalmus</i>	<i>Crotophaga sulcirostris</i>	<i>Geococcyx californianus</i>
11	15	3	4	22
12	40	10	2	2
13	2	----	----	----

Notwithstanding this variation, there is a preponderance of 12 fused vertebrae in the synsacrum of *Coccyzus* and of 11 in *Geococcyx*.

When one is dealing with articulated skeletons, there can be no doubt about the precise number of free caudal vertebrae. Intraspecific variation in the number of free caudal vertebrae is illustrated as follows:

No. of free caudals	Number of specimens				
	<i>americanus</i>	<i>Coccyzus erythrophthalmus</i>	<i>Crotophaga sulcirostris</i>	<i>Geococcyx californianus</i>	<i>Coua caerulea</i>
4	----	----	2	----	1
5	39	11	3	20	2
6	18	3	1	2	1

In addition, Milne-Edwards and Grandidier (1879:170) reported that generally there are seven free caudal vertebrae in *Coua*, but recognized that there might be less than seven due to fusion of one or more with the pygostyle. In the musophagids mentioned previously, the number of free caudal vertebrae varied from five to seven. Burt (1930:477) found from five to seven free caudals in certain woodpeckers.

It would be superfluous to comment on intraspecific variation in length of the individual long bones of the appendages. Further detailed studies (Ashley, 1941) on the configuration of these bones, and of the amount of variation therein, however, would yield information valuable to the anatomist, taxonomist, and the paleontologist. The avian skull has been studied in great detail, but little has been published on variation in that structure (see Shufeldt, 1887).

It is not redundant to stress the value in having large series of completely articulated skeletons in order to determine the normal limits of variation in bony elements. With a box of disarticulated skeletal elements, how can one be sure that all of the cervical or free caudal vertebrae are present? Berger (1955b:302) commented: "Tabula-

tion of the number of fused vertebrae in the synsacrum (a difficult and, perhaps, unreliable determination in the adult bone) may be meaningless unless one also presents the numbers of cervical, dorsal, and free caudal vertebrae; the total number of bones in the vertebral column may be the same in two specimens of a species even though there may be variation in the numbers of vertebrae in adjacent regions." At the same time, in a report on three genera of American cuckoos, Berger (1952:519) found that "there appears to be no significant correlation between the number of fused vertebrae in the synsacrum and the number of free caudal vertebrae." Further data are needed on other groups of birds. It is certainly true that the number of free caudal vertebrae or the number of fused vertebrae in the synsacrum of a single specimen has little significance beyond reporting the condition in that specimen. Contrary to Shufeldt's assertion (1888: 332, 347), there is no justification for the statement, which appeared in a recent taxonomic paper, that "a diagnostic feature of the Corvidae" is the presence of 11 fused vertebrae in the synsacrum (Ripley, 1955:143). In the synsacra of 63 skeletons of corvids, representing 13 genera, I found that 42 synsacra each had 11 vertebrae and 21 had 12 vertebrae. For a recent discussion on skeletal variation in the Anseriformes see Verheyen (1953).

ANGIOLOGY

It can be said with little fear of contradiction that the blood vascular system is the most variable system in the body. The reasons for this variability lie in the embryological development of that system.

Blood is carried to the upper extremity through a major channel, which, for purposes of description, is given different names in successive regions: the subclavian, axillary, and brachial arteries. At the elbow, the brachial artery typically divides into two terminal branches, the radial and ulnar arteries. Certain branches of this main stem have a distinctive course or supply particular structures; these branches are given specific names. There are many unnamed branches, referred to as muscular branches; they are variable in number and position. The definitive radial and ulnar arteries are preceded by other arteries in the human embryo which, each in turn, serve temporarily as the dominant arterial channel; these are the anterior interosseous, median, ulnar, and superficial brachial arteries. The anterior interosseous and the median arteries undergo retrogression and usually are small vessels in the adult. Most of the proximal portion of the superficial brachial artery degenerates. The antebrachial portion of this artery makes a secondary connection with the brachial artery near the elbow to form the definitive radial artery. Such an ontogenetic pattern in the development of the arterial system readily accounts for the variations or anomalies seen in the laboratory. One may find a very large, rather than a minute, median artery. The proximal portion of the superficial brachial artery may persist, so that either the radial or the ulnar artery appears to be a direct continuation of this trunk; or it may give rise to both the radial and ulnar arteries, in which case this division takes place high in the arm rather than at the elbow. An accessory ulnar artery may be present. These are but a few of the many examples which might be cited from human anatomy.

The important feature in the above discussion is that none of the variants represents wholly new channels: all were present as main channels or plexuses during embryological development. They are anomalies in the adult because normal retrogression, or allied processes, did not occur. In the development of an organism as elaborate as a bird or mammal, such minor deviations from a genetically established pattern are not very surprising.

For purposes of description, the subclavian artery is divided into three parts. Two cervical arteries, one from the first part, the other from the third part, supply the same

areas. Each of these two is said to have about 50 per cent occurrence; in some individuals both are present, although they are not usually the same size. One would not attempt to classify man on the basis of the presence or absence of these arteries, or on their relative size.

Developmentally, the aortic arches are bilateral structures. The definitive adult pattern of the aorta and the major arteries of the heart is the result of retrogression, shifting, and recombination of channels already present and the establishment of some new connections formed from pre-existing vascular networks. Essentially, one might say that nothing new had been added. Needless to say, many anomalies are encountered. The interested reader may consult Piersol (1930:724-726), Barry (1951), Woodburne (1951), and Patten (1953:632, 673).

I doubt that "the site of attachment of the intercostal or thoracic artery" in birds "may come to be used as an index in specific levels of evolution" or that "the medial migration of the thoracic artery appears to have some phylogenetic significance" (Glenny, 1955:543-544). Such variation is to be expected in the vascular system. In spite of the vast literature on the main arteries in the region of the heart, ornithologists still await the publication of a carefully executed paper describing the arterial and venous systems of birds. Names of arteries mean little if one cannot visualize their position. Such a paper should describe in detail the origin, course, relations, and destination of each artery (or vein), as in any text book of human anatomy. This treatment would be valuable and most welcome to all ornithologists interested in anatomy, because, among other things, it would serve as a basis for comparative studies.

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FROM FIELD AND STUDY



Clark Nutcracker (*Nucifraga columbiana*) incubating at a nest in a mountain mahogany bush on Reserve Peak, 8500 feet, Mono County, California, March 26, 1956. Photograph by Ray Quigley and James B. Dixon.

Additional Unrecorded Specimens of *Neochloe brevipennis* from Oaxaca, México.—

When Miller and Ray (Condor, 46, 1944:41–51) described *Neochloe brevipennis browni* from Guerrero, they summarized the available information for this species of vireo. At that time six specimens of the nominate form had been recorded. Stresemann (Condor, 49, 1947:210) reported a seventh from Orizaba, and Loetscher (Condor, 54, 1952:204) an eighth from Jalapa, Veracruz. Briggs (Condor, 55, 1953:156–157) extended the range of the nominate form by reporting eleven specimens from Amatepec, Oaxaca. As no additional information has been available for the species, we therefore feel justified in reporting an additional ten specimens from three localities in Oaxaca. Nine of our specimens from two localities, Moctum [= Sta. María] (November 29–December 29, 1941) and Totontepec (April 4–29, 1942), come from areas adjacent to the northeast and southwest, respectively, of Amatepec and are in the same range as Cerro Zempoaltepec. All were collected by Mario del Toro Avilés.

The altitude given by Briggs (*loc. cit.*), namely, 2100 meters, is probably only approximate since the Millionth Map, N.E.-14, of the American Geographical Society shows the altitude of Amatepec as 1690 meters. Although our specimens do not have the altitude indicated, we feel rather safe in assuming that it would not differ greatly from that at which the Amatepec specimens were collected. All the specimens from Moctum and most of those from Totontepec seem to be typical *N. b. brevipennis*.

However, one specimen from the latter exhibits an extensive amount of clear olive green on the lower back and was therefore sent to Dr. Alden H. Miller for comparison. In his letter of January 5, 1956, Dr. Miller states: "The specimen . . . is close to the type of *browni* in the amount of green on the lower back. The gray of the breast is, however, considerably darker than *browni* and the white of the belly area is narrower." He then gives bill measurements of the Oaxaca bird (table 1). In conclusion Dr. Miller states: "The culmen is much more curved than in the type of *browni*, a matter of significance, along with bill dimensions, which leads me to state that the Oaxaca bird is *N. b. brevipennis* rather than *browni*."

The tenth specimen from Tamazulapam, collected by Chester Lamb on July 9, 1943, at 6000 feet, tends to fill the gap between the two races and, as might be expected, shows characters somewhat intermediate between the two forms. This bird completely lacks the clear olive green on the lower back, but the feathers are somewhat worn. The gray of the breast is somewhat lighter than in the Moctum-Totontepec series, although this may be due in part to the more advanced state of wear. The gray of the dorsum is similar. The white of the belly area appears to be somewhat wider, but there is a great deal of individual variation in our series in this regard that may be the result of the different methods of the preparators. Although the culmen is quite large (table 1), it has the curve characteristic of *brevipennis*.

Freshly plumaged specimens from Moctum show the anteriormost nasal feathers to be white, a character not heretofore mentioned by previous authors. After careful comparison of our entire series,

Table 1
Measurements of Males of *Neochloe brevipennis* in Millimeters

	Culmen from base	Bill from anterior edge of nostril	Bill depth, maximum	Bill width at nostril
<i>browni</i> , type				
Mus. Vert. Zool. 112926	11.2	7.0	3.3	3.1
<i>brevipennis</i> , Moore Coll.				
Tamazulapam				
37692	11.3	6.8	3.9	3.4
Moctum				
30927	10.3	6.2	3.3	3.2
30928	10.4	6.2	3.4	3.2
30929	3.5
Totontepec				
33512	10.7	6.4	3.6	3.3
33513	10.6	6.4	3.6	3.2
33514	10.7	6.3	3.9	3.3
33515	10.6	6.4	3.6	3.2
33516	10.5	6.5	3.5	3.2
33517*	10.6	6.3	3.5	3.4

* Measurements by Dr. Miller confirmed by authors.
Other conventional measurements are of no significance in distinguishing subspecies and were therefore omitted.

in some instances with the aid of a hand lens, this character was found to be constant. Dr. Pierce Brodtkorb was kind enough to check the eight specimens available to him from Amatepec and confirmed our findings. It should be mentioned, however, that as the season progresses these white feathers become yellowed and tend to wear off.

Miller and Ray (*loc. cit.*) give a good account of the area in which *browni* was discovered. Chapman (Bull. Amer. Mus. Nat. Hist., 10, 1898:26) and Loetscher (*loc. cit.*) also give us a good idea of the habitat requirements and song of *brevipennis* at Jalapa. Loetscher further states that his male taken on May 4 was in breeding condition. Our male from Tamazulapam taken on July 9 has the tag notation: "testes full size." From this information we can assume that the breeding season extends at

least from early May to mid-July. Virtually nothing else is known of the life history of the species.

It is interesting to note that of the thirty reported specimens of the species, twenty were collected by Mario del Toro Avilés within a few miles of Cerro Zempoaltepec. It might also be mentioned parenthetically that Miguel Alvarez del Toro, a resident ornithologist of Tuxtla Gutiérrez, informed us that he is quite certain that he has seen this species in the liquidambar region of the mountains of Chiapas.

We wish to express our thanks to Dr. Alden H. Miller and Dr. Pierce Brodkorb for courtesies extended us.—ROBERT T. MOORE and DON R. MEDINA, *Laboratory of Zoology, Occidental College, Los Angeles, California, March 15, 1956.*

Nesting of Trumpeter Swan in the Lower Copper River Basin, Alaska.—In the summers of 1954 and 1955 field observations were made on nesting Trumpeter Swans (*Cygnus buccinator*) in the lower Copper River Basin, Alaska. Measurement of three abandoned eggs obtained in 1954 afford proof of species identification and establish the existence of hitherto unknown breeding grounds of the species. The nearest proven nesting area is in the vicinity of Grand Prairie in western Alberta.

The Copper River lies in south-central Alaska and is the largest stream discharging into the Gulf of Alaska. The lower portion of this watershed passes through the precipitous glaciated Chugach Mountains. There it is confined to a comparatively restricted valley which broadens as it merges with the flats of the delta. The observations on swans were made in this lower portion between longitude 145°30' and longitude 144°00' W at latitude 61°00' N, where the Bremner and Tasnuna river valleys converge with the Copper River.

An early record of the Trumpeter Swan and its eggs collected in Alaska is that by Mr. Lockhart at Fort Yukon (Dall and Bannister, *Trans. Chicago Acad. Sci.*, 1, 1869:294), but this record is now considered doubtful. Gabrielson (Auk, 63, 1946:103) reported one dead bird positively identified as a Trumpeter Swan from Ward's Lake in southeastern Alaska found on April 4, 1945. On September 30, 1949, two swans mistaken for Snow Geese were shot by a hunter in the Chickaloon Flats on the Kenai Peninsula. Both birds were positively identified as Trumpeters. On September 15, 1952, F. Glaser (personal communication) reported seeing two Trumpeter Swans with several cygnets on a small lake in the Gulkana River drainage in the upper Copper River Basin. Mr. Glaser identified these birds as Trumpeters by their call.

On June 9, 1954, a swan's nest containing one egg was observed by me from the air in the lower Bremner River Basin. It was built in a clump of grass in the center of a relatively small, shallow marsh lake. This is the earliest date a nest containing eggs was recorded. No adult swans were seen in the immediate vicinity at that time. That evening, however, a pair of large swans passed about 100 feet over camp. Both birds, perhaps alarmed by our presence, uttered a resonant blaring cry. This incident was repeated on several occasions. Because of their large size and unique cry these birds were believed to be Trumpeters.

On the evening of June 12, two pairs of swans were sighted on a sand bar along the river. Both pairs were performing what was believed to be a courtship dance. The nearer pair, about 150 yards away, stood facing each other. With wings arched but not spread to full length, they proceeded to rotate in a circle while their heads bobbed up and down in rhythmic motion. This dance continued for approximately five minutes before it was interrupted by our attempt to move closer.

On July 28, while conducting aerial salmon surveys on the Bremner River, I sighted six pairs of swans in widely dispersed lakes. Three of the six had young, one pair with six cygnets, and two pair with three each. Although cygnets were not observed with the remaining three pairs, their young could very easily have been hidden in the tall grass along the lake shore.

At 4:00 a.m. on June 15, 1954, a pair of swans was sighted from a base camp on Bell Lake near the mouth of the Tasnuna River. Their behavior seemed to indicate that they were mating. This pair departed and flew toward the west end of the lake where later in the day I discovered a swan's nest. The nest lay on top of what appeared to be an abandoned muskrat house, which was situated in a willow thicket bordering a shallow, marshy slough. It was constructed primarily of grass and down and had an estimated inside diameter of eighteen inches and a height of about three feet. It contained three large, creamy white eggs, which were partly stained and concealed by down. Care was taken not to disturb the nest. No swans were seen in the vicinity at this time.

On June 17, three swans flew over camp. Two of the birds were very large, while the third was smaller by comparison and thought to be immature. It is believed that these were the same birds seen on several occasions in the vicinity of the nest. Their blaring cries were identical to those heard previously on the Bremner River. On this day the nest was visited again. It still contained three eggs, but an abandoned egg was discovered lying half buried in the mud near the base of the nest. This egg was salvaged for future measurement.

The Tasnuna River area was not visited again until July 28. That day a pair of adult swans with two cygnets were seen from the air on a small lake near the nest. Several hours later the nest was checked from the ground. It contained two unhatched eggs and it was apparent that the nest had been abandoned for some time. The remaining eggs were salvaged.

Bent (U. S. Nat. Mus. Bull. 130, 1925:284, 297) lists measurements for swans' eggs as shown in the following table.

Species	No. eggs	Egg measurements in mm.	
Trumpeter	25	Average	110.0×71.1
		Extremes	119.5×76.0
			115.0×76.5
			101.0×62.8
Whistling	94	Average	106.9×68.2
		Extremes	115.7×68.5
			115.0×73.0
			90.0×58.7
Tasnuna River specimens (= Trumpeter)	3		120.0×77.0
			124.0×77.0
			120.0×77.0

The measurements of the eggs taken from the Tasnuna River exceed the extreme dimensions given for Trumpeter Swans and thus provide basis for identification as Trumpeter eggs.

In 1955, on July 6, four pairs of nesting swans were seen from the air on four separate lakes in the lower Bremner River area. Three of these nests, built on what appeared to be abandoned muskrat houses, were on small marsh lakes. The remaining nest was built on the ground at the far end of a narrow peninsula on a relatively large lake. On July 16, one of these nesting pairs was seen with four cygnets.

On August 8, 17 adults and 4 cygnets were carefully observed from the ground at close range with field glasses. None of these swans possessed the yellow or orange lore. Without exception the head and a portion of the neck showed a slight rusty coloration. Of 13 birds in one flock, 11 were smaller by comparison than a pair of large swans accompanying them. It is believed that the small birds in this flock were immature and unmated. The remaining four adults were paired, one pair having four cygnets. When the flock of 13 was approached, one of the swans uttered a short resonant call and the entire flock proceeded to crowd or group together. When pursued further, all of the swans, with the exception of the two larger birds which were molting, took to the air.

Three additional swans and four cygnets were observed on August 9. A photographic record was obtained of one molting bird at a range of 25 feet. It was an exceedingly large swan with foot prints measuring $7\frac{3}{4}$ inches long. As noted on the preceding day, none of these swans had the yellow lore.

While flying aerial salmon surveys on August 11, in the Tasnuna and Bremner river basins the writer counted a total of 69 adult swans and 15 cygnets. Five pairs had broods comprised of 4, 4, 3, 2, and 2 cygnets. Because of the dense vegetation and their gray coloration, the cygnet count is not considered accurate. Most of the swans were paired with the exception of two distinct flocks, one of 6 and the other of 10 birds.

Most of the swans had departed by September 28, when a limited aerial reconnaissance was made of the area. However, the four pairs of nesting swans observed on July 6 were still at their original small marsh lakes. The cygnets by this date were much larger in size but still possessed their grayish coloration. Since they had not moved from their original nesting locations, it was assumed that at this date the cygnets were unable to fly.—MELVIN A. MONSON, *United States Fish and Wildlife Service, Anchorage, Alaska, May 22, 1956.*

The Current Status of the Starling in Nevada.—True to the pattern of spread and establishment described by Kessel (Condor, 55, 1953:49–67) the Starling (*Sturnus vulgaris*) has become a breeding bird in Nevada after having been an increasingly abundant migrant and winter visitant for several years. Cottam (Condor, 43, 1941:293–294) first reported this species in the state at Las Vegas, Clark County, on August 12, 1938. By 1949 Starlings had been reported from the Reno and Fallon areas in western Nevada and the Overton, Boulder City, and Beatty areas in southern Nevada (Linsdale, Condor, 53, 1951:242; Marshall and Alcorn, Condor, 54, 1952:321).

In southern Nevada the species has increased from the rare individuals reported prior to 1951 to flocks of several hundred birds which now occur commonly around Las Vegas, in the Overton-Logandale area, and in the Virgin Valley west of Mesquite.

Except for Cottam's first record, a bird reported from the Pahrump Valley, Nye County, on June 27, 1947 (Johnson and Richardson, Condor, 54, 1952:358) and a record from Elko, Elko County, on June 17, 1955, all of the records to date have been for migrant or wintering birds in the lower and warmer western and southern parts of the state. These records have extended from October to early April.

Within the past five years Starlings have been noted wintering, or at least occurring during the winter months, in nearly all parts of Nevada. In addition to the numerous records from the warmer sections, wintering records for the higher and colder regions have been obtained as follows: Goldfield, 5600 feet elevation, Esmeralda County, November 21, 1951; Lovelock, 3900 feet elevation, Pershing County, November 15, 1954; Battle Mountain, 4500 feet elevation, Lander County, January 18, 1955; Duck Valley Indian Reservation, 5400 feet elevation, Elko County, March 19, 1955; O'Neil Basin, 6000 feet elevation, Elko County, April 5 and November 5, 1955; Contact, 5800 feet elevation, Elko County, November 18, 1955; Emigrant Pass, 6100 feet elevation, Eureka County, November 30, 1955; Eureka, 6400 feet elevation, Eureka County, and Duckwater, 5400 feet elevation, Nye County, both on December 1, 1955; Adaven, 6000 feet elevation, Nye County, December 2, 1955; Ely, 6300 feet elevation, White Pine County, December 3, 1955; Elko, 5100 feet elevation, December 5, 1955; the canyon of the East Fork of the Owyhee River near Mountain City, 5600 feet elevation, and the Duck Valley Indian Reservation (200 to 300 birds in one flock), both in Elko County, December 21, 1955; Elko, February 24, 1956; and McGill, 6200 feet elevation, White Pine County, February 27, 1956.

During the period from November 20 to 26, 1955, an especially heavy migration of Starlings through the Elko area was noted, with flocks of several dozen birds each flying low over the ground, moving westerly down the Humboldt River Valley, at a frequency which must have reflected totals of many hundreds of birds a day.

The final record which establishes the Starling as a breeding species in Nevada was obtained on May 17, 1956, when a bird was seen darting into a hole under the eaves of the abandoned schoolhouse in Jiggs, 5400 feet elevation, 28 miles south of Elko. Returning to this site on the 18th to verify the fleeting observation of the day before, I found at least one parent bird taking food into the nesting hole and carrying droppings from it. It was impossible to look into the nest, but from the calls within the cavity, it is believed that at least three nestlings were present.—GORDON W. GULLION, *Nevada Fish and Game Commission, Elko, Nevada, May 21, 1956.*

Mobbing of an Attacking Scrub Jay by a Mockingbird and a Red-shafted Flicker.—At Hancock Park, Los Angeles, on the morning of June 7, 1956, I observed an interesting interrelationship between bird species. A fledgling Mourning Dove (*Zenaidura macroura*), well feathered but obviously unable to fly, was vainly attempting to ward off the attacks of a Scrub Jay (*Aphelocoma coerulescens*). The dove would raise its wings and strive to face the jay as the latter circled, seeking an opening. Suddenly a Mockingbird (*Mimus polyglottos*) swooped down upon the jay, driving it from its prey. A second attack by the mocker forced the jay to retire temporarily under a nearby bench. As the jay returned to its original pursuit, it was again attacked, this time by a Red-shafted Flicker (*Colaptes cafer*). Another assault by the mocker followed. At this point a movement on my part caused both the mocker and the flicker to disappear. I terminated the action by removing the dove from the scene. All of the participating birds were silent for the entire duration of the incident.

I find it difficult to interpret the actions of the Mockingbird and the Red-shafted Flicker. It has been suggested that these birds demonstrated a type of group anxiety or mobbing behavior which was aroused by the actions of a predator, in this case, the Scrub Jay.—LORING DALES, *Los Angeles, California, July 8, 1956.*

Rose-breasted Grosbeak in Arizona.—On May 13, 1956, a male Rose-breasted Grosbeak (*Pheucticus ludovicianus*) was seen at a feed tray in Madera Canyon, Santa Rita Mountains, Arizona. Mrs. Alexander, who maintains the tray, said it had been coming for three days previously. There were many Black-headed Grosbeaks feeding also. On the following day, May 14, a male Rose-breasted Grosbeak was seen near Patagonia, Arizona. It hardly seems likely that it was the same bird since Madera Canyon is some miles away on the other side of the mountain. An early previous record of this species which is a vagrant in Arizona is that of a male taken on June 29, 1894, in the Huachuca Mountains (Swarth, *Pac. Coast Avif. No. 10, 1914:60*).—FLORENCE THORNBURG, *Tucson, Arizona, July 6, 1956.*

Additional Records for the Imperial Valley and Salton Sea Area of California.—In the period from 1945 to 1956, Edward O'Neil of the Salton Sea National Wildlife Refuge, William Anderson of Los Baños, California, Bruce E. Cardiff of Rialto, California, and I have gathered the following records for the area around the southeast end of the Salton Sea and adjacent area of the Imperial Valley, California. All specimens referred to by number are in the Cardiff collection at the present time.

Falco columbarius suckleyi. Pigeon Hawk. A female, number 2428, was taken in a cultivated area northwest of Westmorland on October 31, 1954. The bird was perched in the top of a dead tamarisk tree near a cotton field. The specimen is typical of *suckleyi* with no bars on the tail, faint bars on the primaries, very dark brown coloration on the upperparts, and heavy streakings on the lower parts. This is the first record of this race for the Imperial Valley, and I could find no records for California east of the desert divides.

Squatarola squatarola. Black-bellied Plover. Many fall, winter, and spring observations have been made and several specimens have been taken between 1945 and 1955 in the vicinity of the southern end of the Salton Sea. Specimens collected are as follows: A male, number 59, taken on a mud flat along the southeastern edge of the Salton Sea on November 30, 1946; two females, numbers 1069 and 1070, were taken from a flock in the same area April 15 and one male, number 1163, was taken on October 9, 1949. Black-bellied Plovers have been observed in every month from October 1 through May 14. A search through the literature failed to uncover any previous records for Salton Sea or Imperial Valley.

Totanus flavipes. Lesser Yellow-legs. Two winter records: A male, number 889, taken on January 29, 1949, on a mud flat along the southeast edge of the Salton Sea north of Westmorland; and a male, number 2105, collected in a marshy area along the edge of the Salton Sea west of Niland on February 28, 1953. There are two other records for east of the Sierra Nevada in California.

Micropalama himantopus. Stilt Sandpiper. A flock of six was observed and two specimens were taken at a small pond around a carbon dioxide well west of Niland on April 3, 1954. They were with dowitchers and Least and Western sandpipers. Others have been observed in the vicinity of the southern end of the Salton Sea on different occasions over the past several years by Edward O'Neil and William Anderson. There is only one other record for the Stilt Sandpiper in California, an immature female taken at Eureka on September 10, 1933 (Condor, 36, 1934:168). The specimens are both females and are numbers 2282 and 2283.

Himantopus mexicanus. Black-necked Stilt. Breeds commonly in the area around the southern end of the Salton Sea. Many nests have been found by Edward O'Neil and others on the Salton Sea National Wildlife Refuge north of Westmorland. Many of the nests were located on borders of fields flooded for leaching. The stilts were also found breeding along the shore and on small islets along the edge of the Salton Sea near Kane Springs on May 16, 1952. One set of four eggs, number 1586, was taken. Stilts have not been reported heretofore as breeding in the Colorado Desert area.

Phalaropus fulicarius. Red Phalarope. A female was found almost dead in a duck-banding trap on the Salton Sea National Wildlife Refuge north of Westmorland on September 6, 1953, by William

Anderson. The specimen was preserved and is now number 2352. This is the first record for the Salton Sea area.

Phalaenoptilus nuttallii nuttallii. Poor-will. This race of the Poor-will has been found by Bruce E. Cardiff and me on two occasions: one, a female no. 539, was flushed in daylight in an open weedy field north of Westmorland near the Alamo River on October 23, 1947. Another female, number 679, was taken in arrow-weeds along a roadside northeast of Westmorland on October 3, 1948.

Asyndesmus lewis. Lewis Woodpecker. Observed on several occasions between October 1 and April 16 in a group of several dead cottonwood and eucalyptus trees north of Westmorland. Two specimens were taken: a male, number 565, April 24, 1948, and another male, number 673, October 1, 1948. This species has not previously been reported from the Imperial Valley.

Xanthocephalus xanthocephalus. Yellow-headed Blackbird. A small breeding colony was found in cattails bordering a small pond near Calipatria on May 15, 1952. About a dozen nests were found, some with young and others with fresh eggs. Two nests and sets of eggs, numbers 1577 and 1578, were taken. This species was also observed and heard singing in a large cattail marsh near the edge of the Salton Sea west of Niland, but no nests were found. This species has been reported as a migrant and winter visitant in the Colorado Desert (Grinnell and Miller, Pac. Coast Avif. No. 27, 1944), but this is the first breeding record.

Spinus tristis. American Goldfinch. A flock of four was observed by me feeding on buds in the top of a cottonwood tree northwest of Westmorland on February 5, 1955. The birds were observed at close range, and there was no question as to their identity. I could find no previous records for the Imperial Valley.

Pipilo maculatus megalonyx. Spotted Towhee. On October 8, 1949, an adult male, number 1153, was collected from a growth of arrow-weeds and salt brush along the New River northwest of Westmorland. The specimen was examined by Alden H. Miller and was found to be of this race rather than *curtatus* which has been recorded on different occasions along the Lower Colorado River.

Junco hyemalis cismontanus. Slate-colored Junco. Observed and taken from flocks of juncos on four occasions: A male and female, numbers 2357 and 2358, were taken from a flock of juncos in a group of tamarisk and mesquite trees north of Westmorland on February 5, 1955; several were observed and two males and one female, numbers 2495, 2496, and 2497, were taken in the same locality November 5 and 6, 1955; and one male, number 2520, was taken in the same locality November 26, 1955.

Junco oreganus mearnsi. Oregon Junco. Two typical male specimens of the pink-sided race *mearnsi* were taken and others observed with flocks of juncos in tamarisks and cottonfields northwest of Westmorland. Number 2426 was taken on October 31, 1954, and number 2516 on November 25, 1955. Others have been observed by Edward O'Neil and William Anderson from early fall through early spring.

Junco caniceps. Gray-headed Junco. Three specimens were taken and others observed northwest of Westmorland. A male, number 2494, and a female, number 2493, were taken on November 5 and 6, 1955, in tamarisk trees along the edge of a cottonfield, and a male, number 2519, was taken on November 26, 1955, in the same area and probably from the same flock of juncos. Two of the specimens are typical *caniceps*, and one is an *oreganus* and *caniceps* hybrid, but mostly like *caniceps* except for pink sides.

Passerella iliaca. Fox Sparrow. A female of the race *schistacea*, number 1914, was taken along the edge of a fresh water marsh near the east edge of the Salton Sea west of Niland on October 5, 1952. This is the first record for *schistacea* on the Colorado Desert. A female of the race *megarrhynchus*, number 338, was taken from a group of tamarisk trees near the southeast edge of the Salton Sea north of Westmorland on October 24, 1947. This likewise is the only record for this race on the Colorado Desert. Both Fox Sparrows were identified by Alden H. Miller.—EUGENE A. CARDIFF, *University of California, Riverside, California, March 12, 1956.*

Off-season, Southern Occurrence of the Black Scoter on the Pacific Coast.—In a recent number of the Condor (57, 1955:121-122) I reported two observations of the Black or American Scoter (*Oidemia nigra*) from the northern coast of Baja California—the first records for México. The

one seen in August was thought to be a non-migrating individual. These observations and this inference have now been confirmed.

On May 27, 1956, I clearly identified a lone drake of this species that was diving in the surf just north of Punta San Jacinto, Baja California, at approximately latitude $30^{\circ} 50' N$. This record extends the range of the species about 24 miles and provides a date intermediate between those of the previous observations in México (April 10 and August 8).

On July 4, 1956, between Cardiff and Solano Beach, San Diego County, California, I saw another lone drake of this species. Like the May bird, it appeared to be in good condition. One peculiarity was that the conspicuous protuberance on the basal half of its bill above was unusually light (whitish-yellow, instead of orange-yellow). It was first seen on the wet beach in company with one Hudsonian Curlew and one Marbled Godwit. Presently it flapped into what may be called the marginal flat-water, just within the surf, where it seemed to feed, presumably on sandcrabs (*Emerita*). Later it flew into the surf and then swam outside.

This July bird was almost surely a non-migrant. The records for May, July, and August tend to bridge over the interval between the known overwintering records (November to April) for California summarized by Grinnell and Miller (Pac. Coast Avif. No. 27, 1944:90-91). It now seems almost certain that on the Pacific Coast, as on the Atlantic, individual Black Scoters occasionally remain south through the summer.

It may well be that the Black Scoter is more prone to this over-summering than the other scoters, for I have not recognized this species during the winter about San Diego and in Baja California, when Surf Scoters swarm and when White-winged Scoters are fairly common. And these last two species are very scarce in summer. Perhaps the summering Black Scoters wander about and thus reach points south of their normal wintering range.—CARL L. HURBS, *Scripps Institution of Oceanography, La Jolla, California, July 5, 1956.*

Recent Bird Records for Nevada.—This note contains new information on the distribution or on the breeding status of thirteen species of birds in Nevada. Specimens mentioned are preserved in the University of Nevada Museum of Biology. Unless otherwise stated the collections and observations were made by the author. Subspecific determinations were made at the Museum of Vertebrate Zoology by Drs. Alden H. Miller, Frank A. Pitelka, and Robert K. Selander. The author is indebted to these individuals for identifying a considerable amount of material submitted from Nevada during recent years. I wish to express my appreciation to Drs. Ira La Rivers and Fred A. Ryser of the University of Nevada for many favors extended the author while in the field and laboratory. Thanks are also due Mr. John S. Spencer of Reno, whose assistance in the field made available the data here presented on the Pigmy Owl and rosy finches, and to Mr. Russell K. Grater, who submitted information on the Lucy Warbler.

Parabuteo unicinctus. Harris Hawk. The only mention by Linsdale (Condor, 53, 1951:232) of this species in Nevada is a sight record by W. Pulich of one at Overton, Clark County, on March 30, 1949. On April 17, 1954, I watched a Harris Hawk at close range as it flew from a cottonwood tree in the dense deciduous growth and soared overhead at the Colorado River floodplain, 500 feet elevation, one-half mile north of the California line in extreme southern Clark County. This species should be expected more commonly as a vagrant along the Colorado River to at least as far north as the area where the present record was made. The environment is essentially the same there as that of the lower Colorado River Valley of southeastern California where the species is "locally common" (Grinnell and Miller, Pac. Coast Avif. No. 27, 1944:104).

Colaptes auratus. Audubon's Woodpecker. Willet. On May 14, 1954, at the north end of Washoe Lake, 5000 feet, Washoe County, Dr. Fred A. Ryser, John S. Spencer and the author saw an adult Willet fly from a nest containing two eggs which was built on a grassy knoll near the lake. To my knowledge this is the first report of a nest of this shorebird in Nevada.

Glaucidium gnoma californicum. Pigmy Owl. Considerable field work in the lower montane forest near Lake Tahoe during 1953 and 1954 by John S. Spencer and the author resulted in the detection of this species at the following localities on the west slope of the Carson Range between 6400 and 7500 feet on dates from July 24 to September 19: Zephyr Cove, Glenbrook, and Sand Harbor on Lake Tahoe, Daggett's Pass, Douglas County, and Marlette Creek, Washoe County.

Detection of these individuals was accomplished by imitation of the whistled note of the species in suitable habitat, which in the Carson Range appears to be open forest of mature Jeffrey pine and/or sugar pine growing with white fir and incense cedar on steep slopes. The two birds encountered at Marlette Creek were evidently a mated pair established on a territory on July 24. The individual of this pair which could not be obtained was assumed to be a female, for it called on a higher pitch than the male (testis 4 mm.) which was collected. It seemed reluctant to leave the area until it had been fired upon. A record from outside the general area of the occurrences mentioned above is that of a male collected in a forest of second-growth Jeffrey pine, ponderosa pine, and mountain mahogany at 6300 feet, three miles west and two miles north of Peavine Peak, southern Washoe County, on November 28, 1953. This individual is assumed to have been vagrant from breeding populations to the west in California, as summer occurrence of the Pigmy Owl on Peavine Peak has not yet been demonstrated. To my knowledge this species has not been recorded previously from Nevada.

Dendrocopos scalaris cactophilus. Ladder-backed Woodpecker. The following records extend the known breeding range of this bird in Nevada approximately 85 miles to the north. On April 10, 1954, a male with testis 8 mm. in length and a female with enlarged ova were taken in a Fremont cottonwood grove at Hiko Spring, 3880 feet elevation, Pahrnagat Valley, Lincoln County. The same day, and also in Pahrnagat Valley, L. Keith Miller collected a male with testis 6 mm. in length and saw several others at 3800 feet, four miles north of Alamo.

Sayornis nigricans semiatra. Black Phoebe. Found breeding at Meadow Valley Wash, 4300 feet elevation, four miles south of Caliente, Lincoln County, on April 11, 1954. Both members of the pair and their nearly-completed nest were collected. The female was adding mud to the sides of the nest as I approached. I am unaware of other breeding records for this phoebe in Nevada.

Empidonax difficilis difficilis. Western Flycatcher. Concerning this species Linsdale states: "Summer resident in small numbers; restricted to canyons at middle altitudes of the mountain ranges." An exception to this generalization was found at Ash Meadows, 2200 feet, extreme southern Nye County. There in 1951 this flycatcher was resident in the shady clumps of Fremont cottonwood and ash growing near the warm water pools at Fairbanks Springs. Individuals sang in the early morning from concealed perches in the thick foliage. A female, weight 9.4 gms. and a male, weight 10.0 gms., were collected on June 16 and 19, respectively. Both birds had gonads in breeding condition.

Hylocichla guttata. Hermit Thrush. Three specimens from southern Washoe County in the University of Nevada Museum of Biology have been determined by A. H. Miller as *H. g. slevini*, a race previously unrecorded in Nevada. A male from Hunter Creek Canyon, 5000 feet, Carson Range, taken on April 3, 1954, is similar to material from the Cascade Mountains of Oregon. A female from the same canyon at 4800 feet collected on May 3, 1954, is toward the race *guttata*. Another male was taken in a dense growth of mountain mahogany in the Carson Range at 5000 feet, four miles south of Verdi on April 26, 1954.

Regulus satrapa. Golden-crowned Kinglet. In an earlier note this species was reported from western Nevada for the first time (Johnson and Richardson, Condor, 54, 1952:358). Since that information was published many more sight records are available and eight specimens have been collected in Washoe and Douglas counties. Specimens were collected in presumed breeding habitat of mature and residual stands of white or red fir in the Carson Range from 6600 to 7800 feet. A significant sight record is that of a fledgling being fed by an adult in a dense pocket of mature white fir at 7200 feet, one-half mile southwest of Daggett's Pass, Douglas County, July 29, 1953.

An individual of undetermined sex taken at 5200 feet in a piñon forest at Geiger Lookout, Virginia Mountains, at twelve miles southeast of Reno on November 25, 1952, and a male collected at 4800 feet, nine miles south of Reno on February 24, 1954, represent birds from small wintering groups which have been noted in the valleys and foothills of southern Washoe County from late October through February.

Recently Miller and Russell (Condor, 58, 1956:76) reported a male in breeding condition taken on May 26, 1954, in Trail Canyon, Esmeralda County.

Vermivora luciae. Lucy Warbler. The following records are given to supplement the meager published data for the Colorado River area (Linsdale, *op. cit.*:242) and to present range extensions for this species to the north in Nevada. At the southern tip of Clark County, 500 feet elevation, from three to ten birds were seen or heard singing near the Colorado River each day from March 29 through

April 1, 1953. A male was taken on March 29. At Hiko Spring, 2000 feet elevation, Newberry Mountains, southern Clark County, two birds were observed closely in cottonwoods on April 14, 1954; this locality is about five airline miles west of the Colorado River. A male was obtained along the Muddy River, elevation 1700 feet, at six miles north of Glendale, Warm Springs area, Clark County, on April 6, 1950. At the same place on April 12, 1954, five birds were seen and a female with enlarged ova was collected. In a letter under date of March 16, 1951, Russell K. Grater of the National Park Service in Boulder City wrote me concerning the Lucy Warbler: "We have collections and records from the Muddy River and vicinity. One [was] collected near Overton on June 27, 1938. [Found] nesting near Overton in May, young [were] seen on June 20, 1938." On April 11, 1954, a singing female with enlarged ova was taken near Meadow Valley Wash at 4400 feet elevation, one mile south of Caliente, Lincoln County. The same day, along the Wash at four miles south of Caliente, six individuals were noted, several of which were singing, in cottonwoods and tree willows. A male with testis 5 mm. in length was shot there by Rex M. Larsen and was prepared by L. Keith Miller, members of our field party. Other individuals were observed in the cottonwood stands at several points along Meadow Valley Wash as far south from Caliente as Rox, Lincoln County, also on April 11. To my knowledge the specimen from near Caliente represents the northernmost known breeding station for the Lucy Warbler.

Dendroica occidentalis. Hermit Warbler. Listed by Linsdale (*op. cit.*) as a transient in Nevada with available records only in the fall. The species is also present in small numbers as a summer resident in the lower montane forest along the west-central state boundary. An adult male and two birds in either adult female or juvenal plumage were present in a group of mature Jeffrey pine at 6400 feet along Bryant Creek, one mile southeast of Barney Riley, Douglas County, on July 8, 1953. A female with enlarged ova and a brood patch was collected at Incline Public Camp, 6300 feet, Lake Tahoe, Washoe County, on July 3, 1954. On the same day at the north end of Crystal Bay, Lake Tahoe, at 6400 feet in the Carson Range at one-half mile east of the California state line, three juvenal birds of undetermined sex were taken in a mature forest of Jeffrey pine, sugar pine, white fir, and incense cedar.

Leucosticte tephrocotis. Gray-crowned Rosy Finch. During the winter of 1953-1954, a mixed flock of rosy finches occupied a mineshaft located at 5000 feet elevation, three miles northwest of Reno, on the south slope of Peavine Mountain, Washoe County. Seven visits to the area were made by John S. Spencer and the author from December 12, 1953, to March 7, 1954. At the time of the first visit approximately 150 individuals comprised the flock. Observations on the general behavior of the birds and their utilization of the shaft were similar to those recorded by Miller and Twining on rosy finches at a mineshaft in Lassen County, California (Condor, 45, 1943:78). Among the specimens collected at the shaft are two males taken on December 21, 1953 (weights: 25.1 and 25.3 gms.), and one male and two females taken on February 2, 1954 (weights: 25.3, 22.5, and 23.1 gms., respectively), which have been determined as *L. t. dawsoni* by A. H. Miller. One of the females of February 2 is of questionable racial allocation but seems closest to *dawsoni*. The race *dawsoni* has not heretofore been recorded from Nevada, although it breeds at high points to the south on the main axes of the Sierra Nevada and White Mountains of California near the Nevada border.

Six specimens of the race *L. t. wallowa* were also taken at the Peavine Mountain locality: female, unweighed, December 12, 1953; male, 24.2 gms. and two females, 21.7 and 23.7 gms., February 2, 1954; and male, 23.1 gms. and female, 20.8 gms., March 7, 1954. To my knowledge only one example of *wallowa* was available prior to this report from outside the breeding area of the race in the mountains of eastern Oregon, that of a specimen collected at Ramsey, Lyon County, Nevada, on November 15, 1941 (Alcorn, Condor, 45, 1943:40).

Leucosticte atrata. Black Rosy Finch. This species was present in the flock at the mineshaft mentioned above on the following dates: December 12, 1953, two males collected; February 2, 1954, female taken (weight, 24.2 gms.) and two males observed; February 20, 1954, three observed; and March 7, 1954, female collected (weight, 22.6 gms.). Prior to this note the species had been reported in the state only from the Jarbidge Mountains, Elko County, where it is summer resident (Miller, Condor, 57, 1955:306).

Passerella iliaca. Fox Sparrow. A specimen of *P. i. sinuosa* was collected at East McNett Ranch, 4700 feet, Fish Lake Valley, Esmeralda County, on March 26, 1951. This race has not been reported previously from Nevada. On February 15, 1954, a female of the race *P. i. umalaschensis* was shot in a

dense thicket of willows and serviceberry at 5000 feet, foothills of the Virginia Range at two miles east of Steamboat, Washoe County, providing the first record of this form from Nevada. The subspecies *P. i. fulva* has been collected at Secret Pass, Elko County, on August 18, 1933 (Gabrielson, Condor, 51, 1949:187). A second specimen of that race for the state was taken on April 28, 1954, at Thomas Creek Canyon, 7000 feet, east slope of the Carson Range, Washoe County. This individual was singing on a slope forested with mahogany, white fir and scattered Jeffrey pine. A male of the rare *olivacea* collected in a willow thicket at Bailey Canyon, 5400 feet, foothills of the Virginia Range at two miles east and one mile south of Steamboat, Washoe County, on March 29, 1954, supplements the single specimen of this subspecies listed for Nevada by Linsdale (*op. cit.*:246) from the Ruby Mountains, Elko County.—NED K. JOHNSON, *University of Nevada Museum of Biology, Reno, Nevada, June 20, 1956.*

Cave Swallow Colony in New Mexico.—In June, 1952, the junior author discovered about 40 live birds, 20 dried mummies, and several nests of the Cave Swallow (*Petrochelidon fulva pallida*) in Goat Cave, about eight miles southwest of the entrance to Carlsbad Caverns, Eddy County, New Mexico. He took two of the well-feathered mummies back for storage in the naturalist's office at Carlsbad Park headquarters.

On July 21, 1953, we found 24 live Cave Swallows and 11 nests in Goat Cave, and two specimens were collected for the National Park Service.

On June 26, 1956, J. Stokley Ligon estimated that there were about 15 pairs of swallows "using" Goat Cave. He took an adult male, which is now number 1998 in his collection.

A month's survey by Kincaid in the summer of 1953 indicated that the closest cave used by Cave Swallows is approximately 293 miles away in southwestern Edwards County in central Texas. Kerr County, Texas, which adjoins Edwards County on the northeast, is the only locality in the United States mentioned for *Petrochelidon fulva pallida* in the American Ornithologists' Union Check-list of North American Birds (fourth edition, 1931:219).

Apparently the Cave Swallow was not identified in New Mexico prior to June, 1952. Time has proved the species to be no mere accidental straggler but a regular, although local, breeding member of the New Mexican avifauna.

We are indebted to J. Stokley Ligon and Robert K. Selander for confirming the identity of the specimens of *Petrochelidon fulva pallida* from Goat Cave.—EDGAR KINCAID, *Austin, Texas*, and RICHARD PRASIL, *Mt. McKinley National Park, Alaska, October 6, 1956.*

Northwestward Vagrancy of the Scott Oriole.—The Scott Oriole (*Icterus parisorum*) is summer resident in the high desert areas of the southwestern United States and México. Occasionally individuals straggle westward toward the Pacific coast of southern California, some even appearing in winter. The most extreme vagrancy known to date is represented by an immature male taken on November 26, 1955, about two miles east of Jamesburg in the upper Carmel Valley, Monterey County, central California. The bird is in fresh fall plumage but with juvenal remiges and rectrices. The feathers show no unusual wear and thus offer no suggestion that the bird had been a captive. The nearest station of record for the species is Santa Barbara (Grinnell and Miller, *Pac. Coast Avif.* No. 27, 1944:432) which is 175 miles to the south.—ALDEN H. MILLER, *Museum of Vertebrate Zoology, Berkeley, California, October 3, 1956.*

NOTES AND NEWS

The Grayson painting which appears in this issue shows Wagler Orioles (*Icterus wagleri*) in a coffee tree. The setting is near Tepic, in Nayarit, México, in January of 1866. This is the twenty-second Grayson painting to be presented in *The Condor*. It is made available through the generosity of an anonymous donor.

The annual index for *The Condor* again was prepared by Mrs. Sylvia L. Thomssen, to whom members are much indebted for this valuable aid.

COOPER SOCIETY MEETINGS

SOUTHERN DIVISION

SEPTEMBER.—The monthly meeting of the Southern Division of the Cooper Ornithological Society was held on September 25, 1956, at the Los Angeles County Museum. The following names were proposed for membership: George K. Bennett, 1230 Hamilton Ave., Palo Alto, Calif., by Karl W. Kenyon; Jackson M. Abbott, 814 Thirteenth St., New Alexandria, Va., Kennedy W. Gilchrist, 2711 Colfax St., Evanston, Ill., James P. Malott, 4911 Epes, Houston 21, Tex., Emil K. Urban, 1305 Vermont St., Apt. 3, Lawrence, Kans., Edward L. Webb, 254 E. Second St., Mesa, Ariz., and Dr. Dale A. Zimmerman, 480 N. Almont Ave., Imlay City, Mich., by Jack C. von Bloeker, Jr.; George Kuns, 317 Strand St., Santa Monica, Calif., and George John Wallace, Dept. Zoology, Michigan State University, East Lansing, Mich., by Alden H. Miller; Marcel Houle, 9601 100th St., Edmonton, Alberta, and Ronald B. Renny, 2030 West Lake Ave., Seattle 1, Wash., by W. J. Sheffler; Walter M. Hagenstein, P.O. Box 12, Medina, Wash., and G. M. McDavid, 1016 W. Oak St., El Dorado, Ark., by F. H. Boynton; Mrs. Margaret H. Mothershead, 520 Orange Grove Circle, Pasadena, Calif., by Walter B. Sampson; Richard Tubbs, 146 La Verne Ave., Long Beach 3, Calif., by Ross Hardy; H. P. Adams, Glenville State College, Glenville, West Va., Frederick W. Allen, Jr., % The Yankee Traveler, Warren Ave., Plymouth, Mass., Charles Banks Belt, 233 Bdw., New York 7, N.Y., Mrs. A. P. Bigelow, % Miss Amy Rinehart, 540 E. 7th St., Oakland 6, Calif., Mrs. Albert T. Case, 888 Lilac Drive, Santa Barbara, Calif., Robert D. Coggeshall, Billington Rd., East Aurora, N.Y., Mrs. Whiteford R. Cole, Jr., 1746 Sulgrave Rd., Louisville 5, Ky., Lawrence David Crowley, 1212 Cascade, Boulder, Colo., Henry H. Cutler, 5 Shelley Rd., Wellesley Hills 82,

Mass., Sylvia A. Earle, 735 Wilkie St., Dunedin, Fla., Miss Marie Elitharp, 221 Ten Eyck St., Watertown, N.Y., Mrs. John H. Espenshade, 1185 Parkview Ave., Pasadena, Calif., Miss Monica Ann Evans, Dept. Biol. Science, Northwestern University, Evanston, Ill., Harry Richard Fevold, 221 S. 13th East, Salt Lake City, Utah, Mrs. Hugh Garvin, 670 Park Lane, Santa Barbara, Calif., Gregory Charles Glynn, 65 Partridge St., Albany 6, N.Y., Ryoichi Haga, West 25, Odori, Sapporo, Japan, Carl F. Hamann, Maple Lane, Aurora, Ohio, Josephine Hanna, 901 W. Cedar, El Dorado, Ark., Stoner B. Haven, 1064 E. Linden, Richmond Heights 17, Mo., Fenn M. Holden, Box 428, Grayline, Mich., Gilbert C. Hughes III, Dept. Biol. Sciences, Div. Botany, Florida State University, Tallahassee, Fla., Clarence S. Jung, 6383 N. Port Washington Rd., Milwaukee 17, Wis., Charles H. Kinsley, 3129 Franklin, San Francisco, Calif., Walter James Lawson, Univ. Natal, Men's Residence, Oribi, Pietermaritzburg, Natal, So. Africa, Robert E. Lemon, % Dept. Zoology, University of Western Ontario, London, Canada, William Ralph Luwe, 309 State St., Mankato, Minn., Donald S. McChesney, 405 Piercefield Dr. (Solway), Syracuse 9, N.Y., Clark Miller, Inwood, W. Va., Allister Muir, % Royal Bank of Canada, Broadway and Cambie, Vancouver, B.C., Albert F. Oeming, Sub. P.O. 23, Edmonton, Alberta, Leon Brayton Polka, Lowell G-13, Harvard College, Cambridge, Mass., D. Hiden Ramsey, P.O. Box 8115, Asheville, N.C., Edgar Vonn Reynolds, 615 Louisiana Ave., Cumberland, Md., Richard Carl Rosche, 48 Dartmouth Ave., Buffalo 15, N.Y., Mrs. Mary Reeve Spear Ross, 455 E. Ridge St., Marquette, Mich., Fred Charles Sibley, R. D. #1, Alpine, N.Y., Norman F. Sloan, 1111 Jasper St., Houghton, Mich., Paul W. Smith, 1428 Prospect St., Mentor, Ohio, Frank B. Smithe, 645 W. 44th St., New York 36, N.Y., Mildred Stewart, 2219 Devonshire Dr., Cleveland 6, Ohio, Reynolds Wardell Thompson, 537 Verna Hill Rd., Fairfield, Conn., Sefton Robert Wellings, M.D., 267 Parnassus Ave., San Francisco 17, Calif., and Leo F. Young, 230 N. 2nd East, Brigham City, Utah, by C. V. Duff.

"Avifaunal Survey of the Upper Rio Tocantins of Central Brazil" was the subject of the speaker, Kenneth E. Stager of the Los Angeles County Museum. His talk was illustrated by Kodachrome slides and study skins.—DOROTHY E. GRONER, Secretary.

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